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ABSTRACT

An attempt is made to elaborate a theoretical base about the functions and effects of embedded support devices (ESDs), considering the extent to which students actually use ESDs. ESDs are a set of activating, structuring, and motivating extras in study materials that are designed to support the individual study process. The report describes the set of ESDs that helps define the didactical elaboration of distance education courses at the Open University of the Netherlands (OU). Earlier research related to ESDs is reviewed, and a theoretical base is proposed. This base, which draws on a cognitive psychological framework, is then used to define the functions and the effects of ESDs, with a further description of methods used to research effects of ESDs. The framework takes into account the role of the reading process, motivation, individual differences, and the task environment. Seven figures and four tables illustrate the discussion. Two appendixes present information about OU publications and key concepts in the research. (Contains 108 references.) (SLD)

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The actual use of embedded support devices in self-study materials by students in a distance education setting

Theoretical base and research approaches

M.M.A. Valcke

R.L. Martens

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OTIC RESEARCH REPORTS.

The Open University offers and develops open, higher distance education at university level. In this development process, special attention is paid to innovations in educational technology. The research in this field is set up by researchers of "OTIC", the Centre for Educational Technology and Innovation (Onderwijs Technologisch Innovatie Centrum - OTIC) which is the R & D part of the Open university.
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The main objectives are in the field of flexible organisation of support, incorporation of support into learning materials, optimizing the link between prior knowledge state and the support needs, and the development of more flexible (and automated) approaches towards guidance oriented evaluation.
This project is part of a cluster of projects aiming at the development of an interactive learning environment in which learning is adapted in a flexible way to the needs and demands of the individual student. In this automated interactive learning environment, account is taken of prior knowledge, particularities of the individual learning process, etc.

Centre for Educational Technology and Innovation
Open University

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"Cognitive scientists now see understanding performance on instructional tasks as crucial to improving basic theory, and instructional scientists now see that improving such performance requires basic theory. Increasingly, also, cognitive scientists and instructional scientists are the same people."
(Snow & Swanson, 1992, p. 584)

1 INTRODUCTION

1.1 Problem definition

Distance education sets forth important conditions when developing educational self-study materials for the student. The delivery of education in a distance education setting is - despite all kinds of technological developments - still mainly based on written study materials. The quality of these written materials, in terms of their didactical elaboration is the major issue of this report.

The research, put forward in this text is set up at the Dutch Open university (Ou), by researchers of the "Centre for Educational Technology and Innovation" (OTIC), in the project "Support by Individual Guidance" (SIG). This project focuses on the evaluation of text-embedded support devices (e.g. advance organizers, adjunct questions, schemes, etc.) in written study-materials for students in a distance education setting. A thorough analysis of a "State-of-the-Art" in relation to support, its functions and potential effects has enlightened the necessity to study in more detail the validity of the functions and effects of embedded support devices (ESD) in study materials (Valcke et al, 1991a).

In this report we present an attempt to elaborate a theoretical base about the functions and effects of embedded support devices. Earlier research in this field is reviewed but a new perspective is taken when presenting our approach. Instead of looking for (product) effects of specific embedded support facilities, we focus on process issues : we want to evaluate how and to what extent students actually make use of embedded support devices. Put in other words, does the high investment in the design of Ou-instructional materials result in supported learning ? Up to this date, this type of research has not been set up at the Dutch Open university. Current Ou-practice in course design is based on rather pragmatic course design models, inspired by the design of course materials in other comparable distance education settings and/or based on independent local elaborations of guidelines, strategies, procedures, etc. Appendix 1 shows a representative set of publications that present the rationale for the instructional design practice at the Ou.

But also beyond the Dutch context, authors recognize the need for this type of research and cite the fact that this research issue is hardly endeavoured in literature. Clyde and others state for instance : "little systematic knowledge is available concerning the ways in which students use distance teaching materials provided to them" (1983, p.4). Winne (1983, p.259) puts the same idea in other words : "To date, the correspondence between how the theorist says learners use instructional stimuli and how learners actually use these stimuli in learning from instruction has been left largely to chance". This fact is striking, taking into account the high investment in the course development process and the fact that study materials have to answer the needs of a very heterogeneous student population.

1.2 Outline of the SIG-project

The first phase of the SIG-project consisted of the elaboration of a state of the art in relation to functions and effects of support in Open Learning Systems. As stated earlier, this state of the art indicated that "the evaluation of ESD" was to be considered as a research priority for the SIG-project.

After this first phase, an instrument was developed to explore and evaluate embedded support devices in written study materials (Valcke et al, 1991b).
This instrument has been tried out with a law course : Introduction to Governmental Law" (Martens, Daal & Valcke, 1991). This first try-out revealed some shortcomings in the study materials at the quantitative and qualitative level in relation to the embedded support devices, but was not helpful to reveal the real functions of ESD and/or the actual use of the ESD, because the opinion of students was not taken into account. The results of the try-out strengthened the need for further empiric research.

1.3 Structure of this report

This report discusses five topics :

- a description of the set of embedded support devices that help to define the didactical elaboration of Ou-courses;
- analysis of earlier research in relation to ESD;
- the elaboration of a theoretical base for our research;
- the use of the theoretical base to define functions and effects of ESD;
- an overview of methods that can be used to research the use of ESD by students in a distance education setting.

In chapter two of this text, we focus on the first topic **'embedded support devices'**.

Chapter three deals with **earlier research about ESD**. This chapter is of importance since it indicates that there is a need for (1) a thorough rethinking of the theory related to functions and effects of ESD and (2) a rethinking of research approaches in this research area.

In chapter four, we focus on the **elaboration of a theoretical framework** that helps to describe and explain how students learn in a distance education setting with written study materials. This will be done along consecutive steps. The theory is at a first level inspired by cognitive psychological approaches; e.g. the Sternberg-approach towards cognitive functioning. But, next to cognitive psychological models, other theoretical frameworks in relation to the role of the reading process, motivation, individual differences, the task environment, etc. are considered and integrated into the theoretical underpinnings. In this way, the base can be laid for an instructional theory of design.

In chapter five, we derive from the theory developed in chapter three assumptions about the **interrelation between ESD and learning**. These interrelations present the hypotheses to be tested in the empirical research-phase of the SIG-project. These interrelations illustrate at the same time how the basic theory, developed in chapter three can be used as an instructional theory of design.

In the sixth chapter, we review a variety of **research approaches and instruments** that can be used to study the actual use of embedded support devices. Criteria are explicitated to make a choice for our own research set-up. A final choice is made for a specific method.

2 EMBEDDED SUPPORT DEVICES : AN OVERVIEW

Embedded support devices (ESD) represent a set of formal and content-related add-ons, extensions and elaborations of the written materials about the learning content. Since they aim at supporting the learning process from the point of view of the student and aim at supporting the teaching process when taking the view of course developers, they can be structured following a traditional model of the teaching-learning situation (fig. 1):

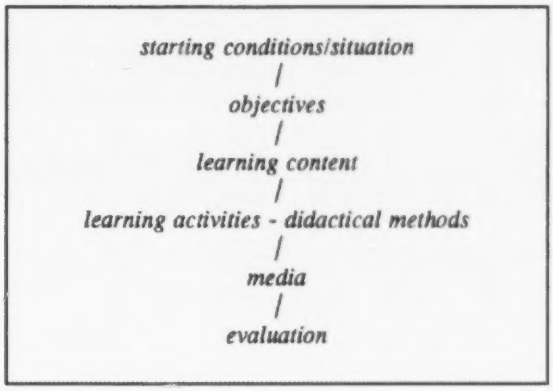

fig. 1 : Model of the learning-teaching situation

In literature, embedded support devices are structured in alternative ways. But, most of these parallel approaches do not put the support devices in the context of the overall teaching and learning situation, but rather centre on specific subparts of this process. Fay & Waller (1976) and Rothkopf (1970) cluster for instance a set of embedded support devices with the concept 'Mathemagenic behaviour'.

Some of the embedded support devices we discuss in this report are not relevant when analyzing specific subparts of study materials; they are only relevant at 'course level' and are part of introductory study guidelines and course introductions. Most of these are grouped in part 2.1. Other embedded support devices are specifically used to support the learners' study process when studying specific text parts; e.g. the learning units. The way the support devices are expected to support the learner are diverse. From the literature and from an analysis of current practice in developing written study materials, we can derive certain functions in relation to each specific support device. In the context of this text part, we will not as yet focus on the potential functions and effects of the embedded support devices (In part 4, we turn explicitly to the functions-issue.). We will rather explain the full set of support devices we envision in our research setting; only parts of the exposition will already be related to the functions and effect issue. To document the overview of the support devices, we will give - if possible - bibliographical references of representative articles that discuss overviews, meta-analyses of the use of specific embedded support devices. Some of these references are not very recent but still relevant; moreover, they are still regularly cited in literature. Among the authors reviewing the literature especially Hartley is of importance. He has tried to put together research in relation to a very large variety of embedded support devices and to extract from this research guidelines to improve instructional text (e.g. Hartley & Burnhill, 1977)
But it is to be repeated and stressed that 99% of the research covered is not set up in a distance education setting. This emphasizes as a consequence the relevance of our research in view of the need to provide validation of current instructional practice.

We distinguish nearly 40 different embedded support devices, but some of them are to be considered as set categories rather than single specific supportive facilities. It has to be noted that sometimes the same text can contain several ESD. In other words the same text can have more than one supportive function.

2.1 Starting conditions

Indications about required prior knowledge
If a course builds on necessary prerequisite knowledge or if prior knowledge about specific topics facilitates studying the study materials, information about this is needed for the student.

Indications about study skills required
The way a student is to work through the written study materials can imply the mastery (or learning) of specific study skills; for example, certain law courses presuppose that the student is skilled in handling multiple law sources, jurisprudence, etc.

References about required prior knowledge
If prior knowledge is required, students can be helped by providing them with references of books, places, tools, ... where they can acquire this prior knowledge.

Starting level tests
if students do not feel sure if they are 'ready' for a certain course, starting level tests are useful. Students can determine for themselves if they meet the starting conditions.

Prior knowledge state tests
Starting level tests measure starting conditions. Prior knowledge state tests are a rather new development (cf. Dochy, 1992) that measure the extent to which students already master the course they intend to study. The test results can be helpful to navigate the student more selectively through the study materials by paying less attention to study contents that are sufficiently mastered. Since the focus on 'prior knowledge state tests' is rather new, we hardly find reviews about pretests (cf. Hartley & Davies, 1976).

2.2 Learning objectives

Course introduction
Course introductions are general orientation sections for students that are helpful to answer questions about : What can I expect from this course ? What are the general aims of this course ? How many time will it take to study the materials (study load) ? What extra support facilities are foreseen next to the study materials ? Etc.

Learning objectives
If defined at an operational level, learning objectives give clear indications about 'what' and 'how' the study content is to be mastered. The phrasing of objectives in observable terms is an important standard. In literature, many researchers have studied the potential benefits of incorporating objectives into the study materials (e.g. Duchastel & Merrill, 1973; Duchastel, 1979; Winne, 1983; etc.).

2.3 Learning content

Structure pages
Structure pages orient the student through the materials. This is especially relevant if the study materials consist of different types of written materials : study book, text book, a reader, additional source materials.

Content pages
The content pages present the overall structure of the learning content. They help to detect interrelations in the course content and help to embed a specific course chapter or part into the broader course content setting.

Both, 'structure pages' and 'content pages', can be considered as 'pre-instructional strategies'. A review of related research about their effectivity can be found in Hartley & Davies (1976).

Repeat-units
Learning units help to recapitulate the course content studied so far. Repeat units can be developed at the micro-unit level and rehearsing only the content dealt with in one specific learning unit. Other repeat units are developed at the meso-level and link together all learning contents discussed so far. The interdependence of the learning content is stressed in this way.

Registers and indexes
Each content domain builds on special conceptual frameworks, sets of agreements, postulations, abbreviations, formulas, and so on. A handsome overview of this information enriches the course content and can present additional access devices to the course content.

Advance organizers
Initially conceptualised by Ausubel (1963), advance organizers are a regularly used support device in written study materials. The fact advance organizers are of higher abstraction level than the course content itself helps to structure, introduce, put into context, etc. the learning content that follows. Advance organizers can be expositive (stressing the agreements) or comparative (stressing differences). Research in relation to the effects of advance organizers has resulted in conflicting findings. Overviews can be found in Barnes & Clawson, 1975; Lawton & Wanska, 1977; Luiten, Ames & Ackerson, 1980; Mayer, 1979; etc.

Schemes
Schemes embrace a large set of complex information into an abstract but more translucent small set of information. Schemes reflect the major 'structure' that is to be found in the information. Some schemes are called 'processes' or a 'classification' if the structured information reflects chronological, hierarchical or comparisons interrelations. In the research literature, the scheme-issue has been extensively studied; we refer for instance to studies of Bernard, 1990; Donald, 1987; Novak, 1990; etc.

Course additions
In certain types of written course, the course content is to be commented. This is especially true if the course if based on a text book of an author who explicitly makes choices, colours information or distorts certain facts.

Content extensions
Next to content additions, content extensions give the student additional information where 'more' can be found since the study materials only deal with part of the existing knowledge of the domain. References of for instance literature, places and people can be useful in this perspective.

References to other learning units
Studying the separate learning units of course materials can invoke a crumbled perception of the course content and as a consequence on the knowledge domain. References to other learning units can help to prevent this.

Text structure
The way written text is structured, divided into text parts, alineas, paragraphs, etc. has an impact on the perception of the basic structure of the domain knowledge. Most research and research overviews about 'text structure' focus on specific elements of this set of support devices; e.g. Bernard, 1990.

Summaries
Summaries can be considered as commented schemes of broader text parts. They compress information to a readable but short outline of the major topics deliberated so far.

Text documentation
Text documentation is a 'set category' comprising pictures, maps, charts, graphs, tables, photos, cartoons, etc.. that help to substantiate elements or parts of the abstract course content. The value of text documentation is especially to be located in an effective way to present multiple representations of the same course content. Many authors have studied this set of support devices : Diagrams are for instance heavily studied (Moxley, 1983; Szlichcinsky, 1979). Also the representation of quantitative information has attracted

attention (Macdonald-Ross, 1977, Wright, 1977). Illustrations and graphics are another major research area (Alesandrini, 1984; Duchastel, 1981; Macdonald-Ross, 1989).

Examples
Examples can be considered as a special case of 'text documentation'. They add to the course content an alternative representation of the same knowledge element.

Formal style / Ou-style
'Style' is another set of support devices. At the Dutch Open university this style is labelled as the 'Ou-style'. Style comprises especially formal text features : font types, font sizes, colour use, title use, margin texts, text subdivision, and so on. If used in a consistent way, 'style' enhances the accessibility of the course content. Frase & Schwartz (1979), Macdonald-Ross & Waller (1975), Waller (1979) and Wright (1977) focus on 'typography'. Hartley & Trueman (1985), Wright (1977) focus e.g. on the role of headings.

Writing style
The fluency of the writing style, the density of information in the sentences, the length of a reasoning, etc. determine the writing style. Choices made in relation to the writing style support or do not support the learner. Research in relation to this kind of support device is not plentiful. Part of the overview of Wright (1977) is related to choice of words, sentences, etc.

2.4 Learning activities

Support devices in relation to study activities can be subdivided into two categories : devices that help to structure and organize the study process (sp) and devices that help to motivate and activate (ma) the student. In the following text we added between brackets (sp) or (ma) to the support devices depending on whether they are considered to support in the former or the latter way.

Indications about study load (sp)
Clear indications about the study load to be expected can help student to structure and plan their study time. The course study load is, in the Ou-context, given in study-hours.

Indications about support provisions (sp)
At the same level, students can also structure their work according to the support provisions, rendered by e.g. study centres, peer groups, etc. The indications comprise information about properties and strategies adopted under the specific circumstances.

Indications about the expected study approach (sp)
The course content can be documented, at the micro-level, with information, indications, guidelines, about the way to tackle the course content, specific subparts of the course content, certain tasks, questions, etc.

Questions, tasks about the study approach (sp)
When discussing the 'Indications about required study skills" we already referred to the fact that studying specific content domains can imply the mastery of specific study skills. But it is also possible to learn students to acquire these skills in the course of their actual study process. But this implies that the course developers incorporates into the study text information on a meta-level when he gives indications about how to deal with the tasks, questions, materials, etc. The example we gave supra about the skills in handling multiple law sources, can for instance be demonstrated in a separate text section before the student is expected to do it on his own.

Pre-questions (ma)
Prequestions are a special support device that present the student questions before actually elaborating the course content in more detail. The questions can help the student to make available the needed prior knowledge. Questions are also helpful to relate the new learning content to information already dealt with or they induce explicit reflection from the student in relation to the new course content. Research about the

potential benefits of incorporating questions into study texts is abundant. For extensive overviews we refer to Bernard & Naidu, 1992; Duchastel & Whitehead, 1980; Hamaker, 1984; Rickards & Denner, 1978; Winne, 1983; etc.). Some of this research is not only related to 'pre-questions' but is also relevant for the use of questions in general.

Questions (ma)
'Questions' is a commonly used type of support device in written study texts to activate continuously the student to question himself about his knowledge, comprehension or mastery of the learning content. The literature references mentioned in relation to pre-questions can be repeated here.

Tasks (ma)
'Tasks' are support devices that demand from the student further actions; especially at application level and going beyond the information presented in the study text. In practice authors distinguish application tasks, ases, construction tasks, action tasks, algorithm tasks, etc.

Feedback (ma)
The learning activity can further be intensified by giving feedback in relation to questions and tasks. Revision, reflection behaviour are incited and can help the student to look at the same study content from a different perspective. In reviewing the literature especially the study of Bernard & Naidu (1992) is of importance in this context since these researchers focused on the combined effect of post-questions, concept-mapping and feedback in a distance education context. A more general overview of research in relation to feedback in relation to self-regulated learning can be found in Elshout-Mohr, 1991.

2.5 Media

Use of additional media, media-mix
The written course text can be appended with information that can only be delivered by other media. Information and references about these media are to be given.

Support to the use of media
Moreover, the student is also to be told what is expected from him when he is studying or working with these additional media.

2.6 Evaluation

Mastery requirements
The expected mastery levels in order to pass examinations are guidelines to help students to estimate their readiness after studying the course content.

Information about test formats
Students are disoriented if they are questioned, evaluated by unexpected test formats (e.g. special types of multiple choice where they expect free format questions). The way they prepare themselves for a test is influenced by this type of information.

Tests (formative, summative)
Examples of tests and examinations give directions about What and How to study.

Examples of (correct) answers
Examples of correct answers have more than an illustrative function. They shape the way students will prepare themselves to answer questions.

3 EARLIER RESEARCH : THEORETICAL WEAKNESSES AND METHODOLOGICAL PROBLEMS

3.1 Introduction

When reviewing earlier research in relation to the functions and effects of specific embedded support devices, we already mentioned some weaknesses of this research body (cf. Valcke, Daal & Dochy, 1991). These weaknesses become even more obvious if we focus on the relation between research and educational practice. In view of the SIG-research objectives, analysis of these weaknesses is relevant to indicate pits to avoid and/or shortcomings to be foreseen. We clustered the findings of the reserach analysis along two major clusters. Chapter 4 and 6 can be considered as the "lessons learnt" from this analysis. Therefore, no immediate conclusions are drawn at the end of this chapter.

3.2 Theoretical weaknesses

3.2.1 The lack of theoretical base

It is striking to note that many research projects and even research overviews in relation to embedded support devices do not pay attention to a theoretical base for embedded support devices. Some authors call this the "atheoretical" attitude (Cordero et al, 1989, p.255). These studies focus on the achievement effects that are the result of a learning process based on study materials with specific (set of) embedded support device(s). Typical examples of such studies are Clyde et al, 1983; Luiten, Ames & Ackerson, 1980; Macdonald-Ross, 1973 & 1977; etc. These studies can mainly be characterized as effect-studies and result in an instructional theory of design that mainly influences the "look" of study materials : "Ironically, the "look" of instructional products has been affected profoundly by this kind of research, in spite of the generally small effect sizes associated with such processing adjuncts." (Bernard, 1990, p.207). But course developers, adopting a pragmatic attitude towards the development of study materials, and working under time pressure, have other priorities in selecting ways of elaborating the study materials. If certain embedded support devices seemingly "work" they are gratefully incorporated into the 'style' of the developer and the developing context.

We do not suggest that the lack of theoretical bases affects negatively current practice. Macdonald-Ross (1977, p.361) stated for instance that "There is plenty of evidence that, on occasion, practitioners can see more truly and deeply than their experimental colleagues. This ought not to surprise us as unduly, for it has often been said that scientific knowledge grows out of a deep understanding the investigator has for the subject under investigation.". Also Waller (1979, p.179) confirms this and says that working with aphorisms can be much more sound for current practice than 'mindless empiricism'.

3.2.2 Reductionist approaches and behaviouristic influences

Focusing on the interrelation between embedded support devices and the learning process suggests a rather reductionist approach with prevailing influences of behaviourist techniques to influence learning. Winn (1990, p.55-56) demonstrates how authors, explicitly stating that they adopt a cognitive psychological point of view, still adhere implicitly to behavioural theory in stating their belief in the possibility to put forward instructional design procedures : the basis of instructional design is task analysis that still carries with it a reductionist approach to instructional decision-making; instructional design principles are considered to be valid and reliable, independent of the specific group of students; instructional design is separated from the implementation of instruction; if design procedures are applied correctly, good instruction will ensue. These principles are acceptable if low-level learning is expected. The design principles become questionable if higher levels of cognitive functioning are pursued. We can add to the critiques of Winn that these kinds of research set-up also reflect behaviouristic influences since they solely focus on external regulation principles of learning. The influence of internal regulation processes (self-directed learning, independent thinking) is hardly considered.
In contrast to these behaviouristic and deterministic assumptions, theories from a more recent vintage stress the importance of - difficult to control - intervening variables (Winn, 1990, p.59-62):

- individual differences
- contextual variables
- the impact of metacognition
- the fact that part of human behaviour remains unpredictable and is even illogical.

From these critiques of Winn, we retain especially the two first, since they refer to intervening variables we are looking for. The impact of metacognition will be incorporated into our model of cognitive functioning. The last critique about the unpredictability of human behaviour will be kept in mind to keep our feet firmly on the ground and to question our sometimes naive theoretical speculations and expectations.

3.2.3 Missing variables

A last critique is related to the former. Since we focus on 'embedded' support devices, there is an extra intervening variable in the processes studied : the reading process (cf. fig. 3). In the research literature, this variable is hardly taken into account.

3.3 Methodological weaknesses

Earlier research methodology focusing on the analysis of functions and effects of specific embedded support devices can be criticized following three different tracks :

3.3.1 The narrow focus on effect studies

It is striking that most evaluative research about embedded support devices focuses on 'product effects' as outcomes of the learning process; e.g. recall, comprehension, time spent studying, higher attrition rates, test-scores, etc. 'Product effects' are rather researched by using quantitative research methods.
There are hardly examples of studies focusing on the changes in the learning 'process' caused by the embedding of support devices. But the latter type of research would imply the use of qualitative research methodology which is much more complex and time-consuming to set up.

3.3.2 Poor ecological validity of contexts and research instruments

The research body in relation to embedded support devices has been heavily criticized because of its weak ecological validity. Much research has been set up in an artificial context, focuses on unrepresentative texts, uses questionable measuring instruments or has never been related to real study contexts (cf. Duchastel & Whitehead, 1980, p.41; Macdonald-Ross, 1977, p.360; Waller, 1979, p.177; ...).

3.3.3 What use is made of embedded support devices?

The validity of research on the effects of embedded support devices can be criticized from another point of view : If learners are presented with text-embedded support, it is not sure whether or not they use or know how to use these support facilities. We may not forget that the student - when working at a distance with written learning materials - has complete veto power over learning (Rothkopf, 1970, p.326). Winne (1983, p.245) states for example when he tries to explain the inconsistencies in earlier research results : "these results may reflect different ways that learners cognitively responded to the instructional stimuli rather than weaknesses in their effects". In order to obtain more valid results, this researcher trains his students to use the embedded support devices (objectives, adjunct postquestions). A similar approach is adopted by Bernard (1990) because he incorporates processing instructions with the graphic organizers and structural cuing he adds to the study text. Also de Jong & Simons (1988, p.178) demonstrate how training in using ESD can enhance the learning process.
At the theoretical level, this research weakness has heavy implications : "If learners do not even respond to these stimuli, theories of instructional effects are well off their mark when they attempt to describe students' cognitive processes that mediate between instructional stimuli. (...) To date, the correspondence between how the theorist says learners use instructional stimuli and how learners actually use these stimuli in learning

from instruction has been left largely to chance." (Winne, 1983, p.258-259)[1].
Moreover, the question is not only whether the students use the support devices or whether they know how to use them, but also whether they need the support provided. They are only useful if students need them. Waller (1979, p.180) mentions e.g. different user objectives when dealing with study texts : entertainment, recapitulation/reviewing, browsing, studying in depth, searching for a particular item, etc. Each user perspective affects the potential effects/functions of ESD.

[1] The research results of Winne (1983) confirm his suspicion towards the question whether or not student use ESD. In his experiments he made use of placebo groups who got the text materials with ESD, but got no instruction on how to use the ESD. Up to 80 % of the students did not use the instructional stimuli (ESD) in the way that previous research has hypothesized.

4 BUILDING A VALID BASIC THEORY

4.1 Opting for a cognitive psychological framework

Putting forwârd a theoretical framework for research in the field of learning and instruction is influenced by prior considerations about the nature of cognitive functioning[2]. We adhere to a 'information processing approach' to cognitive functioning which implies a cognitive psychological view on learning. Cognitive psychological theories are dynamic in nature, help to describe (hypothetical) processes in detail, admit autonomy of the individual learner and incorporate constructivist views on learning. The latter characteristics are important since they show how the theory can be linked to intra-individual variables and particularities of the instructional setting of the Open university : distance education, self-instruction, independent learning, etc.

In literature attempts to build a comprehensive cognitive psychological theory can be found. The 'cognitive schemata theory of self-instruction' of Martin (1984) is a typical example. His theory is not related to the design of the instructional setting, in casu the impact of embedded support devices. But his theory can be used as a relevant base for the development of a cognitive psychological theory of instructional design. Therefore we will return to his schemata theory later.

Of course, cognitive psychological theories focusing more specifically on the impact of embedded support devices can also be found in literature, but most of them remain restricted. They are mainly conceptualisation in relation to one specific type or set of embedded support devices. Hamaker (1984) refers e.g. to three cognitive processes : memorizing, integrating and elaboration when he discusses the role of adjunct questions; Novak (1990) refers to a set of metacognitive strategies when revealing the impact of concept maps and Vee diagrams; Hewson & Posner (1984) developed a (schema) theory about the use of schemes, slots; etc. Some researchers do not develop a theory but present rather a general frame of reference.

The variety in theoretical frameworks can be related to the variety of different embedded support devices or sets of devices each researcher focuses on. Since we centre on a large variety of embedded support devices, a more elaborated and comprehensive theory is needed, comprising the theories/processes commonly found in literature.

Some theories in literature are of this more general nature. Vermunt & Van Rijswijk (1988) do for instance not focus on specific support devices but focus on the interrelation between the learning setting and the development of students' skill in self-regulated learning. Their componential analysis of the learning setting has been helpful to identify on the one hand processes in relation to the course content and on the other hand regulation of learning. Although their research priority is on the identification of learning styles and the development of an instrument and study advisory packet to influence students' learning styles, their work is also related to the impact of embedded support devices. A basic conception of the authors is about the predominant role of self-regulation in learning (cf. Vermunt, 1991). This influences their view on the expected restricted value of such in-built support facilities. Nevertheless, their theoretical work is of importance and will be considered when elaborating our theory.

Our theory is based on the componential theory of Sternberg (1980, 1985, 1988) to describe and explain cognitive functioning. We opt for the Sternberg-approach since he stresses, in one consistent framework, the importance of a large complex of cognitive processes : knowledge acquisition components, performance components and metacognitive components. In linking this theory to the functions and effects of embedded support devices, the models/theories of other authors, mentioned above, will be considered.

4.2 A theory of instructional design : the need for a valid basic theory

When discussing the embedded support devices in chapter 2, we already anticipated on potential role(s) they

[2] In appendix 2, the reader can find a list of key concepts frequently used in the further parts of this text.

can play when supporting the learning process. These roles are mostly based on hypothetical expectations. Our research focuses on questions concerning these hypothetical links between the embedded support devices and the underlying processes that build on them or are being influenced, resulting in 'supported' learning. There is an urgent demand for an elaboration of this issue. Recent research questions the validity of the implicit or explicit assumptions about the relevance of a variety of embedded support devices (e.g. Vermunt, 1991; Lowyck & Simons, 1991). The demand these authors put forward for a more sound "theory of course design" can hence not be answered before a more basic and valid theory is available that describes and explains the learning process in the instructional setting. Snow & Swanson (1992, p.284) state this as follows : "Cognitive scientists now see understanding performance on instructional tasks as crucial to improving basic theory, and instructional scientists now see that **improving such performance requires basic theory.**". Snow & Swanson indicate clearly that an instructional theory of design can only be successful if it exploits a valid basic theory that helps to describe and explain how students learn and how this can be related to key variables in the instructional setting.
The theory of instructional design Snow and Swanson envision (1992, p.590) considers and integrates multiple variables in relation to the learner and the learning context. They define the following matrix of key interacting variables :

aptitudes x learning types x content domain x instructional designs x situations x populations

Our research tries to fill in such a matrix by constructing a theoretical model for specific cell contents :

aptitudes	: cognitive, affective & conative
learning type	: independent studying from written study materials
knowledge domain	: law domain
instructional design	: distance education based on written materials enhanced with ESD
situation	: open learning
population	: adults

But reconsidering the rationale developed above, this matrix needs underpinning by a more basic theory that describes and explains how adults learn independently law from written study materials enhanced with ESD in the open, distance education setting as defined by the Open university.
Three concepts in the matrix refer to rather less variable conditions:
- the law-domain is defined by the specific elaboration of a course content;
- open and distance education are defined since we refer to the Ou-context.
But three other concepts and their interrelations remain unclear and need further refinement in the basic theory : learning (aptitudes), the ESD in the written study materials and variables related to the adults intending to study.

In the next part of this chapter, we will explore the types of aptitudes to be incorporated into the basic theory when describing and explaining how learning occurs. This will be done in close connection to the issue 'written study materials' since we focus on learning from text. Next, we will focus on individual differences to incorporate the concept adults into the model.

4.3 Learning from text : aptitudes

Focusing on the interrelation between embedded support devices and learning, we can depict our main research issue as follows (fig. 2):

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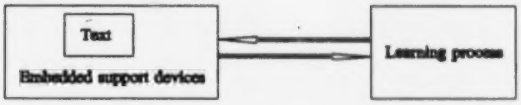

fig. 2 : Basic interrelation in our research

Since we focus on 'written' course materials as the communication channel along which learning is incited, a central question about the impact of embedded support devices is how 'reading' a text - enriched by these embedded support devices - is related to learning. It is obvious from this research question that the complex interaction between E.S.D and learning is made much more complex because of the interference of variables related to the reading process (fig. 3).

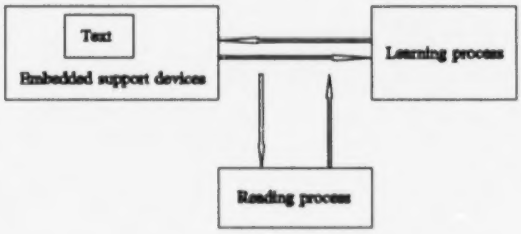

fig. 3 : Extension of the basic interrelation

An attempt to describe and/or explain the role and function of embedded support devices must therefore involve, next to considerations about the learning process, also aptitudes related to the reading process. First, in part 4.4, we will focus solely on cognitive aptitudes that can be helpful to describe and explain the learning process. In part 4.5 we will extend the set of (cognitive) aptitudes with processes related to reading.

4.4 Cognitive aptitudes and learning

As stated earlier, we adopt the Sternberg-theory as a main frame of reference to describe and explain cognitive processes related to learning. The cognitive processes (components of cognitive functioning) he describes are, according to our idea, the processes that are responsible for the representation of knowledge, the interaction with knowledge in memory and knowledge needed to solve problems, the refinement, elaboration, ... of knowledge representations, etc.

We will elaborate this chapter part to a high extent because we want to compare our approach with the one of other authors before opting for and presenting a first conclusion.

Cognitive functioning is - according to Sternberg - described with the concept 'components'. A component is "an elementary information process that operates upon internal representations of objects or symbols" (1986, p.225). Sternberg distinguishes three groups of components :

- Performance components (PC);
- Knowledge acquisition components (KAC);
- Metacognitive components (MC).

Metacognitive components control, evaluate and plan the activities of the other components. They are executive processes. The knowledge acquisition components are involved when new information is getting integrated in already available information in memory. This integration process implies encoding, combining and comparing. Performance components are those processes that operate when a task is actually executed. Knowledge acquisition and performance components are non-executive processes.
The metacognitive components can be perceived as "the stage directors that tell the actors - the performance and knowledge acquisition components - how to act. The actors in turn provide feedback to the directors about how the show is going. (Sternberg, 1987, p.189)".
Table 1 gives a more extended overview of these groups of components. The PC are grouped as stages when executing a task. They can be of a rather general nature but also be rather domain-specific.

Table 1 : Components of cognitive functioning : The Sternberg model

Metacognitive components (MC)	Knowledge Acquisition components (KA)	Performance components (PC)
1. Recognizing that a problem exists	1. Selective encoding	1. Stimuli encoding
2. Recognizing the nature of the problem	2. Selective combining	2. Combination or comparison between stimuli
3. Selecting lower order components for execution of the task	3. Selective comparing	3. Applying
4. Selecting a strategy for task performance		
5. Selecting a mental representation		
6. Deciding to allocate attentional resources		
7. Monitoring		
8. Understanding internal or external feedback		

These groups of components are also reflected in other theoretical approaches we already referred to earlier in this text. Vermunt & Van Rijswijk (1988, p.550-657) make for instance a distinction between processing of course content and processes related to regulation of learning. Martin (1984) distinguishes in his model three levels of embedded, cognitive schemata that are conceived as exerting executive metacognitive and cognitive control in the selection of declarative and procedural knowledge structures/networks that, in turn, instantiate the schemata.
If we compare these theoretical approaches to the Sternberg-model, we get the following picture :

Table 2 : The Sternberg-model compared to alternative theoretical approaches

Sternberg	Vermunt & Van Rijswijk (1988)	Martin (1984)
Performance components - stimuli encoding - combination or comparison of stimuli - applying	**Processing of course content** - selecting - relating - concretizing - analyzing - structuring - personalizing - being active - memorising and rehearsing	**schemata of tasks** organized along phases of self-instruction : - goal setting - creating information structures - preassessing - mapping task domains/objectives - planning - maintaining action - evaluating and building on declarative knowledge networks
Knowledge Acquisition Components - selective encoding - selective combining - selective comparing		
Metacomponents decisions in relation to - existence problem - nature of the problem - lower order components - strategy task performance - mental representation - allocation resources - monitoring - feedback	**Regulation of Learning** - orientating - planning - monitoring - testing - diagnosing - repairing - evaluating - reflecting	**Multi-option metacognitive schema** that influence the self-instructional schemata and build on procedural knowledge structures (cognitive-behavioral skills and strategies)

Although there is a parallelism between the three theories, there are also obvious differences. Vermunt & Van Rijswijk do e.g. not distinguish between performance and knowledge acquisition components. The specific processes they distinguish already suggest that they do not differentiate these aspects. Moreover, it is possible to relate the Vermunt and Van Rijswijk processes to the components Sternberg differentiates. Depending on the specific temporal combination of his components, the complex of cognitive processes can be identified as relating, concretizing, analyzing, and so on. The Sternberg-components can therefore be considered as cognitive processes of a higher abstraction level which are the basis for the more concrete cognitive operations identified by Vermunt & Van Rijswijk.

The theory of Martin (1984, p.163) builds on a very different conceptual frame of reference; a key concept is 'schemata'. Schemata are collections of propositions organized into prototypic forms for procedural and declarative knowledge. A very important class of schemata is the class of plans. A plan is a set of sequenced cognitive operations that we apply to information in order to complete a task. The schemata are executive cognitive operations that need to be instantiated by specific memory content. This 'content' can be classified at the one hand as procedural knowledge structures (cognitive-behavioral skills and strategies) and at the other hand as declarative knowledge (semantic information in areas relevant to self-instruction) both specific to the substantive area within which self-instruction is attempted. Interesting is also the fact that Martin pays attention to 'situational information' that influences the self-instruction process.
The importance Martin pays to seven phases of the self-instruction process originates from his conception of 'self-instruction'. In his view, it is the student who takes all initiative in relation to all decision features of the instructional process (for instance stating objectives, choosing the learning content, selecting learning activities, representation modes).

In our conception of independent learning, major importance is attached to the in-built support in the written study materials. The degree of autonomy is therefore rather restricted compared to the Martin-view. Another

major difference between our conception of learning and the Martin-view, is in relation to his phasing of the self-instruction process. Although we admit that a mapping of the learning-process - at a macro level - along phases can be acceptable, we prefer to describe the learning process as a recursive process in which cognitive operations continuously interact in a network.

Considering the Sternberg-theory in relation to the approaches by Vermunt & Van Rijswijk and Martin, we opt for using the original Sternberg-model, but without the differentiation between the knowledge acquisition and performance components (figure 4).

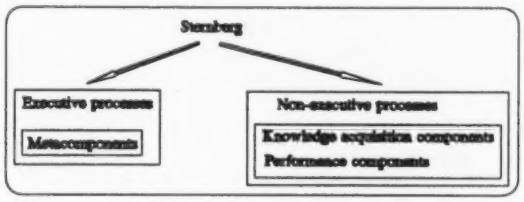

fig. 4 : The adapted Sternberg-model

This dual focus on the learning process is consistent with our view on the concept "influence on learning" when we refer to the key concepts of our research set-up as elaborated in appendix 2. Already at that level we distinguished support-features in relation to the specific learning process and support in relation to the meta-level of learning to learn.

In chapter 5, we will relate the cognitive aptitudes, stated thus far to the ESD. In our view, ESD influence specific (sets of) cognitive processes and can therefore result in a positive effect of exhort a specific function.

4.5 Reading : an intervening process

As stated earlier, the interference of the reading process in our research cannot be neglected and is even to be incorporated into our model. Of course, in the context of this study, it cannot be our intention to discuss the reading process in detail. We only focus on those aspects of the reading process that are related with studying, learning. As a consequence we centre on 'discourse comprehension' and not on the decoding aspects of the reading process. This decoding process is, in experienced adult readers an automatic process, that probably hardly causes individual differences, although there might by an indirect influence. Although at this level reading and listening have become very similar (Kintsch & van Dijk, 1978; Perfetti & lesgold, 1977), we will only focus on the comprehension of written texts (discourse).
In this text part, we restrict ourselves to an introduction into recent and main developments in the area of discourse comprehension in order to be able to relate these reading theories to our theoretical model. Those interested in additional information can find extra information in the literature referenced.

4.5.1 Discourse comprehension

Discourse comprehension is a complex process that still is not effectively comprehended by theorists. In recent attempts computer models are built to simulate the process. These simulation programs remain restricted and can be compared to the still imperfect attempts to automate the translation of texts.
Obstacles in theory construction and research of discourse comprehension is the measurement issue end speculations about the number of 'factors' that can be used to describe this reading skill. Recent theorists adhere the view that the skill is based on a single factor, called 'verbal intelligence',causing individual differences (Rost, 1989). Despite the heavy debates on this issue, there is a certain agreement about the - minimal set of - 'building bricks' constituting a model for discourse comprehension. Kintsch (1988, p.163) : "Discourse comprehension, from the viewpoint of a computational theory, involves constructing a representation of a discourse upon which various computations can be performed, the outcomes of which are

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commonly taken as evidence for comprehension. Thus, after comprehending a text, one might reasonably expect to be able to answer questions about it, recall or summarize it, verify statements of it, paraphrase it, and so on.".

At this level, we already perceive cognitive processes that can be related to components of cognitive functioning as described by the Sternberg-model.
Kintsch continuous : "To achieve these goals, current theories use representations with several mutually constraining layers. Thus, there is typically a linguistic level of representation, conceptual levels to represent both the local and global meaning and structure of a text (e.g., the micro- and macrostructure, constituting the text base in van Dijk & Kintsch, 1983), and a level at which the text itself has lost its individuality and its information content has become integrated into a larger structure (e.g., van Dijk & Kintsch's situation model)."

Figure 5 gives a schematic overview of the overall construction and functioning of the discourse comprehension model as found in literature (Ballstaedt, 1981). In this figure, the text is the input of the process and the cognitive schemata form the output. The micro- and macrostructure of the text represent subproducts of the comprehension process.
The process starts from a 'text'. This text is decoded : words, meaningful units are extracted from the text. If a text is comprehended and letters/words are turned into meaningful, but still isolated units (micropropositions), these units are combined and a read thread is constructed that runs through the text.
The decoding process is done at local text level; small text parts are taken step by step. When words have become meaningful units (but still isolated), these units are combined and the red thread that runs through the text is reconstructed. This implies a certain reduction of the initial text content. Moreover, in order to comprehend the text, the reader doe also have to know even more than the actual text content. Inferences and elaborations have to be made. Inferences are text additions constructed by the reader; elaborations are inferences that go beyond the minimal information needed to understand the text (e.g. the reader makes a pictorial representation of the main character of the story). Finally, these processes result in a set of cognitive schemata about the text content.

It is taken for granted that the process, described above is of a cyclic nature. Text parts are processed part by part. At the end of the cyclic process, the complete text is comprehended. It is also important to note that there is no strict hierarchy in the processes and building bricks described. All processes influence each other. Of course understanding a text starts with reading the first sentences of a discourse ('bottom-up) but always immediately expectancies, schemata and ideas from the reader start to play an important role (top - down). Moreover, the interpunction of the overall process is not unidirectional; text comprehension does not only start from a newly read text (bottom-up), but is also initiated from existing and available cognitive schemata (top-down). If people read for instance some new text, that is consistent with their content expectations, the text will be read and comprehended at a much faster rate, compared to texts with unexpected content parts. Taking into account these latter remarks, it is to be stressed that the model in fig. 5 is a simplification of reality. The layered structure and process flow suggested in the model, represent rather 'one' possible conception of the comprehension process, compared to processes and the structure in real life. This strong interrelatedness of structure elements, layers and processes is depicted in figure 7 with arrows : the large arrows represent information flows. The curved arrows suggest a possible process run.
It must be stressed again that there is no theoretical agreement yet and this moment there neither is strong evidence for any of the developed models of reading comprehension. There is probably still a long way to go before the process is really understood.

Figure 5 represents the complete scheme of the comprehension process. The outcomes of the process are represented as 'bricks', the process elements are depicted with ellipses.

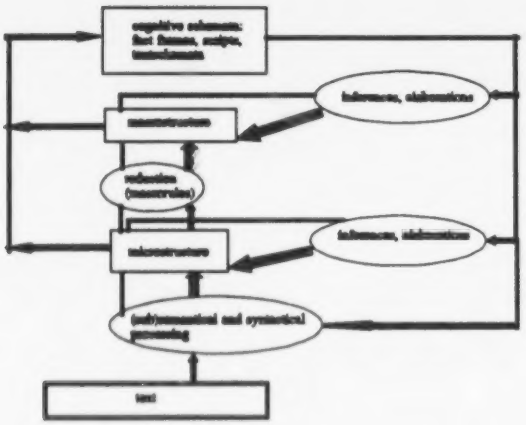

fig. 5 : Schematic representation of the building bricks and processes in the comprehension process (based on Ballstaedt, 1981)

A major publication in the discourse comprehension literature is Kintsch & van Dijk (1978). In this publication, they present the model described above. The model shows how a reader builds a coherent global text meaning from isolated text propositions. The rules, followed through this process are called "macrorules". This model, with minor or major adaptations is still used and still influential in current research and literature (e.g. Britton & Gülgötz, 1991; Oostendorp en Peeck, 1991, etc.).

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4.5.2 Reading and learning

Parallelisms can be found between both processes at the level of the nature of input and output and at the process level. Differences are striking when the 'intentionality' and 'finality' of both processes are clarified.

- Parallelism between the nature of **input and output** of the learning and comprehension process
When recapitulating the comprehension process described above, and looking at the learning process in the context of distance learning, based on written study materials we see that both processes mainly start from a 'text'. At the output level, both processes result in the construction of 'knowledge' (comprehension). Following the Sternberg model the knowledge acquisition components result in coded, combined and compared representations. The comprehension process described earlier results in cognitive 'schemata'. These schemata are comparable to the 'representations' in our conceptual frame of reference. But of course, since students, when learning, are expected to go beyond the mere text content by answering questions, executing tasks, etc. the final output of the learning process will be much more complex.

- Parallelism in the **process aspects** of the learning and comprehension process
Since learning from text is based on comprehending the study text in order to extract meaning, in order to perform specific learning processes there is at consecutive stages an overlap between both processes.
If we concentrate on the - in time and function - overlapping cognitive processes between learning and reading (comprehension), we can state that the processes described along the Kintsch and van Dijk model are comparable to the processes in the Sternberg model. Figure 8 depicts the possible overlap between both processes in the course of a learning process. Since both processes, in starting from a text, are directed towards meaning construction, the three groups of cognitive components can be used to describe the subprocesses described in the Kintsch & van Dijk model. In reading, metacomponents are active : there is the problem to be recognized and solved, its extent is to be stated, attentional resources are to be allocated, the process is to be monitored, specific strategies for task performance are to be selected, etc. (cf. Markman, 1979). The knowledge acquisition components are in game when the cognitive schemata are build, step by step, by encoding, combining and comparing (cf. the macrorules of Kintsch & van Dijk). Performance of the selected strategies for task performance is to be guaranteed by encoding, combining and comparing (text) stimuli and applying task specific activities.

- Differences between the comprehension and learning process
As stated earlier, there is not a complete overlap between the reading and learning process. Learning goes beyond mere reading and comprehending since the learning activated in the text goes beyond the mere text content. Students are expected to solve questions, execute tasks, look for resources or extra documentation, etc.
Also the kind of reading, implied by learning is in a way different from reading in general. The type of reading on which learning is based differs from other types of reading by its special 'intentionality'. Reading for studying is for instance different from reading as a leisure activity or reading to search for specific information (van Hout Wolters & Kerstjens, 1990). Reading, when linked to learning can be considered as a kind of extended reading. Just & Carpenter (1987, p. 424) state the interrelation between reading and learning as follows : "Many study strategies can help readers understand the text's content and organization and relate it to what they already know, including rereading, outlining, and networking. These strategies are closely related to normal comprehension processes; they require elaborating on and making explicit the kinds of informational structures that readers construct during comprehension.".
So, the difference between both processes is to be found in the intentionality of the reading process. Oostendorp & Peeck (1991, p. 153) describe this as follows[3] : "...when reading there is not always a learning intention. This means that the process is not directed towards changing a cognitive structure.

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[3] Translation by the authors of this article.

Learning is always directed towards changes in cognitive structure.". The special intention of learning is also found in the larger stress that is put on the incorporation of knowledge representations (cognitive schemata) into the memory structure in order to remember what has been read. Many research (Gernsbacher, 1985; Lorch & Lorch, 1985; Mandler & Johnson, 1977; Thorndyke & Yekovich, 1980; etc.) stressed this special interrelation between comprehension, learning and remembering.

In summary, learning can in part be considered as a special case of discourse comprehension that is focused on changes in knowledge acquisition (representation and retention).
Boonman & Kok (1986, p. 64-70) adopt a similar view and have in parallel constructed an extended reading model (figure 6). The interesting thing about their model is that they offer us the opportunity to anticipate on our discussion about the potential role of ESD in learning from text. Next to technical reading and text comprehension they discern 'reading for studying'. Here, the learner/reader goes beyond the text and starts processes that are labelled as 'in-depth analysis' which imply repeating, transforming and elaborating[4].

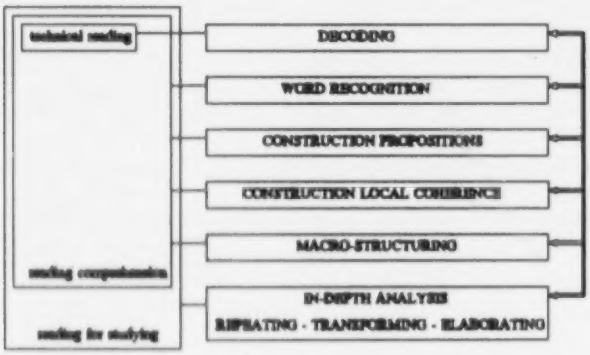

fig. 6 : Model of reading for studying (Boonman & Kok, 1986, p.69)

[4] Note the parallelism between their conceptual framework and the schema theory of Anderson in which learning is approached as a process during which schemata are transformed, tuned and refined (Anderson, R.C., Reynolds, R.E., Schallert, D.L. & Goetz, E.T., 1977; Anderson, R.C., Spiro, R.J. & Anderson, M.C., 1978).

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4.5.3 Individual differences

Since discourse comprehension is related to learning, reading ability does correlate to a high degree with achievement. Reading ability correlates with school achievement results and general intelligence indicators (Rost, 1989). Individual differences in reading ability are therefore an important intervening variable in the process of learning from text. In literature, (e.g. Singer & Donlan, 1989) 'types' of readers are distinguished. If we look at the building bricks of the model for the reading process, differences between readers can be related to specific elements or process parameters. Oostendorp & Peeck (1991) have derived a long list of differences. It is also important to note that differences between readers can be important and are difficult to overcome (Rost, 1989; Singer & Donlan, 1989) :

- There are differences in the semantical and syntactical base. Less able readers possess for instance a less elaborated vocabulary. They do not only understand concepts to a lesser degree but the slower and non-automatic word recognition process invokes an extra bottleneck by putting too heavy demands on the capacities of the short term memory (cf. also Perfetti & Lesgold, 1977).
  Differences in grammatical knowledge hinders of course text comprehension.
- Differences in speed and accuracy by which concepts are recognized and put in context.
- Differences in prior knowledge (cf. Dochy, 1992)
- Differences in cognitive functioning (components in the Sternberg model).

Next to differences in relation to cognitive aptitudes. Oostendorp en Peeck also mention differences that go beyond the mere cognitive aptitude differences :

- Differences in interest.
- Differences in motivation (differences in attitudes towards the text content).

As stated before it should be noted that these differences do not occur isolated. Individuals lacking one of these 'abilities' usually lack others.

4.6 Extending the set of aptitudes beyond the cognitive : Motivation

Next to cognitive aptitudes related to learning and reading, also affective and conative (action control) aptitudes play a role. We already referred to such non-cognitive aptitudes when discussing individual differences in relation to reading comprehension. At the more general level of learning, non-cognitive aptitudes are to be taken into account. When we look e.g. at the impact of affective and conative aptitudes on the learning process and context, especially 'motivational' issues are of importance.

The literature in relation to 'motivation' is a still growing and vast area of research and theory construction (Ames & Ames, 1984; Boekaerts, 1987). Before indicating and/or selecting those elements that are of importance for our work terrain, we have to repeat that we develop a theory about adults who learn independently in a distance education context. This implies that we take for granted that certain pre-conditions in relation to motivation and regulation are already met :

- the student opts on an informed base for independent learning;
- the student is an adult who has already (implicitly or explicitly) developed certain learning strategies;
- the student studies on the base of written study materials in which the ESD guide, activate, direct and motivate learning.

Implicit in our conception is the belief/expectation that students have reached a certain motivational level and are able to direct their own learning process. On the other hand, we perceive and expect the ESD to play a major function in this area. The ESD are foreseen to scaffold the motivation of students. These expectations can be questioned. We review some major criticisms :

- Attribution theories (cf. Weiner, 1979, 1984) and the self proficiency model (Heckhausen, 1974) indicate that **motivation** is influenced in a cyclic way depending on success and/or failure experienced during the learning process. Since in written study materials there is no interactive feedback communication channel along which information about success or

failure is delivered, realistic attribution, realistic estimation of mastery levels or progress is not possible (van Hout Wolters, 1991, p. 287).
- When criticizing earlier research, we already quoted Bernard (1990) who stressed that providing learners with support devices does not imply they will actually use them. This introduces the controversy about the impact of externally offered versus internally chosen action control stimuli. This discussion is linked, to a certain extent, to the dispute about internal versus external regulation. Vermunt (1991, p.323) indicates e.g. that especially internal regulation directs learning and questions external regulation by using ESD.

In contrast to these criticisms or reservations towards ESD, a variety of authors nevertheless indicate that ESD in written study materials can have an impact on action control and motivation. In 1979 Waller (p.183) already refers to motivational effects of typographic access structures for educational texts. van Hout wolters (1991, p.288) mentions for instance that motivation can be enhanced by stating operational objectives, the attractive elaboration of the study materials (style, fonts, graphics, illustrations, graphics), the incorporation of questions/tasks, indicating the relevance of the learning content to future professional contexts, etc. Elshout-Mohr (1991, p.309) mentions course introductions, tasks to make students reflect on study strategies, corrective feedback, content pages, structure pages, additional secondary representations of learning content, tasks, indexes with keywords, etc. We return to this issue in chapter 5.

4.7 The task environment

The task environment refers - at a general level - to those variables that define the setting in which the student studies. Of particular importance in the context of this article is the fact that we focus on students studying in a distance education setting. Independent learning and self-instruction are supposed to be key features to attain learning objectives. The availability of additional resources, peer students, supervisors, tutors, ... is normally not a standard feature of this setting.
The task environment also refers - at a more specific level - to the expectations, constraints, mastery levels, general objectives, pre-suppositions about prior knowledge levels, etc. put forward in relation to a certain course. The 'situational information' Martin (1984, p.175) refers to, can also be regarded as being part of this task environment. In our theoretical model, the task environment is put next to the individual variables. Both are closely interconnected.

4.8 A model for learning from text, enriched with embedded support devices

If we integrate the theoretical considerations, discussed so far, we can build a model for learning from text, enriched with embedded support devices[5]. This model comprises :

1. The interacting cognitive aptitudes (components) as described in the Sternberg model and as reformulated in part 3.4 of this text.
2. The fact that learning is based on studying from text. This implies the integration of cognitive reading-related aptitudes in the model.
3. The influence of non-cognitive aptitudes (motivation).
4. Variables in the individual learner that are difficult to control but interact with study behaviour and the way the study text is perceived, used and processed.
5. The impact of context-variables which help to define the task-environment.

Figure 7 gives a pictorial representation of a model, representing the key variables in our basic theory :

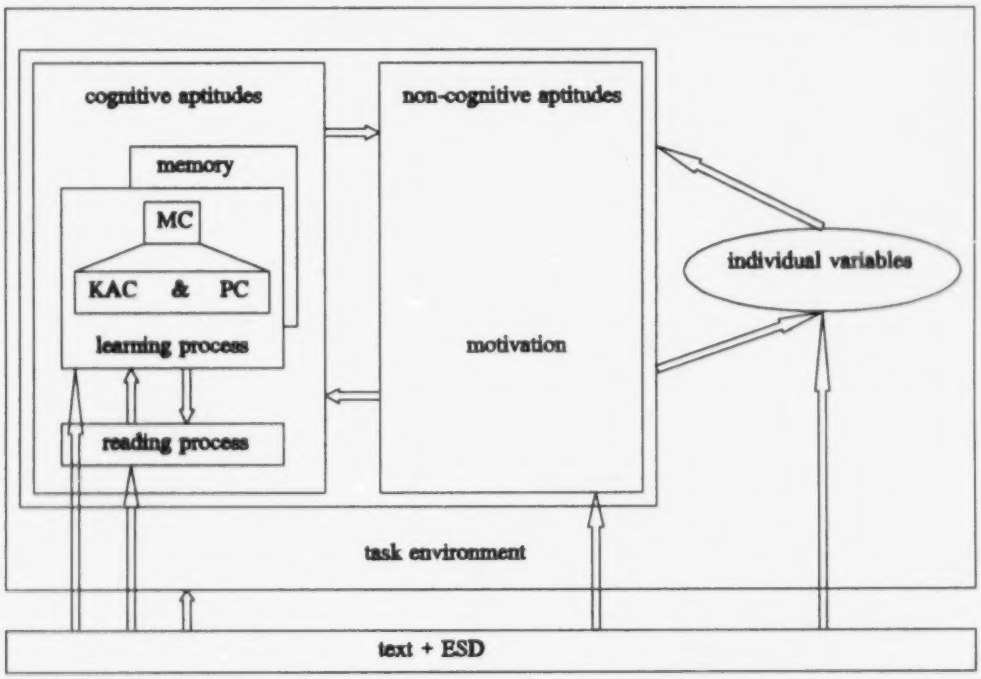

fig. 7 : A model for the distance learning situation based on written study materials

One aspect in our model has not been dealt with in detail : variables in the individual learner that are difficult to control. We incorporated this aspect to deal with the differences in prior knowledge, intentions, interest, professional background, ... of students of the open university. It is expected that this set of variables can influence they way student learn. This has, in the context of our study, to be related to the way they use (or do not use) the ESD in the written study materials. The impact of these variables will be

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5 de Jong & Simons (1988) also present a "model of self-regulated learning during text processing". There are striking parallelisms between their and our model but the main differences are related to our attention paid to the task environment, individual differences, non-cognitive aptitudes and the integration of an extra set of cognitive aptitudes (KAC & PC).

controlled for in our empiric study when we analyze in detail how, when of whether student use ESD. To illustrate the latter we can refer to a study of Cordero et al (1991, p.268). These authors discovered e.g. that product effects of objectives and outlines were contorted by differences between research groups due to differences in prior knowledge "the subject's prior low level of knowledge of the text topic seems to have dimished intergroup differences which otherwise might have emerged.".

The reader can criticize the model and theory developed so far by indicating that no mention has been made of the role of the memory. In our model we intended especially to stress the interrelation of process variables during learning. Memory is - in our perception - rather a 'structure variable', a storage device for declarative and procedural knowledge. Access and use of memory is stated in terms of the MC, PC and KAC components. Therefore, memory is put 'behind' the process-structure of the learning process.

The model in figure 7 clearly indicates where ESD can have an impact : they can influence single processes (e.g. cognitive aptitudes in relation to reading) or sets of aptitudes. In chapter 5 we will operationalize these interrelations in more detail and try to illustrate the potential functions and effects of ESD.

5 OPERATIONALISING THE MODEL
COMPONENTS OF COGNITIVE FUNCTIONING AND EMBEDDED SUPPORT DEVICES

As Sternberg stresses (1988, p.302) the "identification of the components of information processing does not in itself give an adequate account (...). One must also identify the strategies into which the components are combined and the mental representations into which the components and the strategies act.". This implies that a thorough reformulation of the cognitive components, in terms of embedded support devices, is needed. Since we added, in our model extra - reading, non-cognitive, individual and task environment - variables, we also have to take them into account when inferring the relevance of the support devices for learning.

When recapitulating the theoretical base, the reader might argue that the pre-dominance of the metacognitive processing components (regulation processes) might pose a problem if we look for a link between ESD and processing. Next to reading related processes, only this category of components launches executive processes at the cognitive level. As such, there cannot be a direct impact of ESD on knowledge acquisition and performance components. But, it is to be stressed that we approach here cognitive functioning from an instructional point of view. Embedded support devices can - according to this view - directly influence knowledge-acquisition and performance components. The meta-components structure, rule, direct, select, etc. out of a repertoire of context-embedded performance and knowledge acquisition components. ESD can affect this repertoire. ESD can directly activate, expand, exercise them. The ESD incite, rouse in this way prototype behaviours, of a knowledge acquisition or performance nature, which are to become integral part of the complex of cognitive processes and are next to be launched, directed, etc. by the metacognitive components.
An extension to this discussion can be put forward in relation to the concept 'Influencing' we presented in appendix 2. We indicated 'influencing' implies that embedded support devices are expected to facilitate learning in order to attain the learning objectives and to develop learning strategies (metacognitive) that are helpful to direct future learning. It can be argued that each attempt to support learning with a particular support device influences learning at both levels. We accept the fact that by simply embedding a particular support device[6] modelling of aptitudes is invoked and the repertoire of knowledge acquisition and performance components is influenced (extended, activated, exercised, etc.).

Infra, we will discuss each embedded support device in relation to our model and question - at the hypothetical level - what kind of cognitive processes can be induced by the specific support device. If possible, we will document this discussion with data from empirical research to give a fermer base to our assumptions. It is to be mentioned that a specific device can induce in parallel or in sequence a variety of cognitive components. Next, we repeat that the hypothetical relationships discussed here have to be put in a larger and more complex setting of the student in a self-instructional environment. The latter suggests that certain embedded support devices do for instance not have a direct impact on the learning process itself but rather on contextual variables, such as the task environment, individual variables and/or motivation. We have to stress the fact that typical embedded support devices might play multiple functions and launch cognitive activities in relation to several cognitive components.

If possible, we document our discussion with examples taken from the literature. A problem with this literature reviewed is that there are differences in the conceptual frameworks used; there are differences when they are compared to each other and when they are compared to our conceptual framework. If - and this is in many studies not the case[7] - authors link the effects of a certain ESD to certain psychological processes, this is done by using different concepts, theories, etc. We have been obliged to do some "translation" work. This "translation" is as much as possible documented in the text; the original concepts,

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[6] It would be entirely different if the support devices were not embedded but had to be developed by the student himself. Novak (1990) gives us such an example. He discusses concept maps and Vee diagrams. But instead of simply presenting these devices to the students, he learns them to create such devices themselves. As a consequence, the cognitive processes invoked during this learning process are rather related to metacognitive components.

[7] Many studies do not focus on the process effects of E.S.D but rather look at product effects in terms of "recall" or "retrieval", learning gains, achievement, etc. A typical example of the latter is the study of Hartley & Trueman, 1985.

etc. are mentioned and our view on the relationship with our model presented. But, we don not follow all opions of every author. In stating functions and effects we try to look for the very specific and possible unique. Some authors tend to give a blueprint where certain ESD influence all processes and variables in our theoretical model.

At the end of this text part we will present a table in which we summarize our analysis results. This table will represent the theoretical, hypothetical statement of the functions and effects of the variety of ESD in our empirical part of this research project, this table is to be confronted with the opinions and the daily study practice of the students. This can result in a validation of the hypothetical functions and effects and/or and adaptation of the theoretical model.

In reviewing the ESD, we use the structure introduced in an earlier publication by building on the 'decision moments' of the learning-teaching situation (Valcke et al, 1991b). This implies that ESD already are clustered around topics suggesting parallel functions and effects.

5.1 Starting conditions

Part of the support devices in relation to the starting conditions can be grouped, since they potentially play parallel functions :

- *Indications about the required prior knowledge level*
- *Indications about the study skills required*
- *References about required prior knowledge*

No theoretical or empirical information on potential functions and effects of these ESD can be found in literature. But referring to our model, we can hypothesize that these devices especially help to clarify the task environment. The specific course is presented to the learner in such a way that he can position the requirements, expectations, ... in the context of his personal expectations, capabilities, etc. As an side-effect also motivational aptitudes can be influenced.

In a comparable way, but at a more operational level, the following support devices also influence the task environment and motivation but especially arouse cognitive and non-cognitive aptitudes :

- *Start level tests (pretests)*
- *Prior knowledge state tests*
- *Study contracts*

The specific functions or effects of these ESD have not been extensively researched :

* Hartley & Davies (1976, p.241) focus on pretests and refer to one special function for the student : "the increase of the sensitivity to a learning situation, it can alert students to issues, problems or events that they ordinarily may not have noticed (...) = alerting function."

* Dochy (1992, p.30) centres on prior knowledge state tests. He states that administering a prior knowledge state test activates the relevant prior knowledge of an individual. This directs the successive learning process. The author enumerates up to 8 theoretical models that describe this facilitative effect on learning; prior knowledge testing is expected to launch the following processes : restructuring, elaboration, accessibility, selective attention, availability, retrieval-aid, schema-transfer and representation-saving.

If we link the ideas of Hartley & Davies to our theoretical model, we can state that these ESD first of all influence the task environment. Dochy, on the other hand rather stresses functions/effects referring to metacognitive components (selection of a mental representation, decide to allocate attentional resources, selection of lower order components for task execution).

5.2 Aims-objectives

Objectives can be stated at a general or at a very operational level. In order to be effective, especially the operational (behavioral) definition of objectives is a pre-condition to influence the learning process.

Therefore, the cognitive processes mentioned underneath are only relevant under the latter circumstances.

- Course introductions

Since course introductions contain general objectives, we refer to the discussion about objectives to spot specific functions and effects.

- Learning objectives (course objectives and operational objectives)

Incorporating objectives into the study text as an aid to learning can be based on a varied set of assumptions about their facilitative effect. In literature, we find a large variety of assumptions underlying the inclusion of objectives :

* Cordero et al (1991, p.257) indicate that stating objectives can exert an influence upon text comprehension and recall.
* Duchastel (1979, p.100) mentions : "objectives increase relevant learning (learning of text elements that are related to the objectives) and decrease incidental learning (elements not related to the objectives).
* Duchastel & Merrill (1973, p.64) present various rationales to explain this facilitative effect which they link to the "selective attention hypothesis".
* Hartley & Davies (1976, p.242) state for instance "behavioural objectives (...) are deliberately designed to facilitate learning and to help generate expectation or learning set towards the task." (...) are meant to inform (...) students of what is finally expected of them.".
* Van Hout Wolters & Willems (1991, p.288) put forward the potential of objectives to incite 'planning' behaviour of students. The same authors and also Vermunt (1989) indicate that stating clear objectives can scaffold the affective (motivational) climate.
* Winne (1983, p.259) mentions the "pointer effect" of behavioural objectives because they ensue better encoding of new information. The learner is being pointed to the concepts needed to learn.
* ...

If we link these findings and opinions to our theoretical model, we can restate these hypothetical functions as follows :

- objectives clearly help to clarify the task environment;
- motivation is aroused;
- the reading process is supported;
- knowledge acquisition and performance components are activated since encoding processes are supported;
- metacognitive components are incited (existence of a problem, allocation of attentional resources, recognizing the nature of a problem, monitoring).

5.3 Learning content

Learning content is - at the meso- and macro-text-level - presented and organised in a certain fashion. There are linkages, hierarchical structures, subdivisions. If students only focus on the micro-text-level, they can loose grip on the overall consistency of the learning content. Certain embedded support devices explicitly invoke cognitive processes that help to grasp both the micro- and meso/macro-text-structure :

- *Structure pages*
- *Content pages*

These ESD incite metacognitive processes in relation to decisions on the information representation mode. Linked to this, these embedded devices can also be positioned as helpful to invoke the knowledge acquisition components 'selective combining' and 'selective comparing'. If students use these devices to browse through the learning content, they apply certain performance components : 'stimuli encoding' and 'combination or comparison between stimuli'.

Reflective metacognitive learning strategies are stimulated by :

- *Repeat-units*

This support device, if the student involves himself in rehearsing, can be considered as monitoring behaviour. If feedback information is available, also components in relation to the understanding of internal/external feedback are incited.

It is rather difficult to indicate what kind of cognitive processes are supported by embedding :

- *Registers and Indexes.*

Elshout-Mohr (1991, p.309) links these ESD to the act of giving 'informative feedback'.
Their impact is hardly researched in the literature. It can be argued that selective encoding (KAC) or stimuli encoding (PC) are stimulated, but the provision of these registers and indexes can also support a metacognitive component : selecting a mental representation.

- *Advance Organizers*

The literature in relation to advance organizers is abundant. As a result, a variety of hypotheses about functions and effects of advance organizers have been put forward. We recount some major views :

* Most authors stress their relevance by the fact that learners are provided with superordinate concepts or principles. Advance organizers give (1) a general overview of what is to be learned and (2) provide organizing elements to link the new to the old (Barnes & Clawson, 1975, p.638).
* Cordero et al (1991, p.257) use "outlines" as synonymous to advance organizers. In their conception, outlines are introductory aids that act on the macrostructure of the text. Their way of reasoning is in the context of our study interesting since they also pay attention to the intervening reading process (reading comprehension). The link to learning is stated as follows : "outlines promote the use of deductive strategies, that stress global comprehension. They activate the conceptual structures into which the text's information is incorporated." It is interesting to look at some of the experimental results of these authors. They set up a 'product' oriented evaluation study to evaluate the impact of advance organizers and obtained significant positive results that inspired them to confirm the hypotheses stated above : the advance organizers seem to have "acted mainly on the structural memory and comprehension and through them on the structural recall" (ibid, p.269).
* Fay & Waller (1976, p.693) state "novel materials will be more readily learned if a conceptual bridge to existing well-established knowledge is provided".
* Hartley & Davies (1976, p.246) mention three functions : (1) ideational scaffolding for differentiated learning tasks; (2) discrimination of learning tasks from related ideas in existing cognitive structuring; (3) integrative reconciliation of old and new information. The same authors also suggest a link with motivational aptitudes but do not elaborate this issue. It can be hypothesized that indicating the link between the new learning content and the already available information in the individual's knowledge base can have a reassuring effect. The 'new' learning content does not arise as entirely new, unknown or different.
* Lawton & Wanska (1977, p.234) refer to cognitive processes such as progressive differentiation, integrative reconciliation in order to induce the assemblation of new cognitive structures.
* Mayer (1979, p.374) discusses three theoretical models to explain the impact of advance

organizers. His most complex model links this ESD to cognitive processes in relation to 'activation' of anchoring knowledge available in memory and 'encoding' to integrate anchoring knowledge and received information. An important concept in this perspective is "retrieval aid".

Relating the opinion of these authors to our model, we can summarize that advance organizers stimulate knowledge acquisition components : the learner is supported and incited to compare and combine stimuli. Comparable processes are activated at the performance level : "Combining & comparing stimuli and Applying".
In relation to metacognitive components, we hypothesize that the selection of mental representations is activated. Finally, there might be an important link with reading comprehension.

When complex information is presented in study texts, it is most relevant to add the following support devices to the text :

- *Schemes (structure-scheme, process-scheme, classification-scheme, concept maps).*

Before entering into a discussion about potential effects and functions of schemes, we have to repeat that this type of ESD can be operationalized in many different ways. This can affect their impact, function and relevance.

* Novak (1990, p.31) considers schemes (concept maps, concept/propositional structures in his terminological framework) as representational tools.
* Bernard (1990, p.208) discusses e.g. a type of schemes he calls 'graphics organizers' which refer to the notion of 'concept maps' (Novak, 1990). In his opinion they aid the assimilation of lower level text content and the recall of it.
* Donald (1987, p.187) Schemata are representations of knowledge "The function of a schema is to allow two kinds of tasks to be performed : to locate or retrieve information and to solve problems".

In cognitive psychological terms, this implies that
- selective encoding (KAC) and stimuli encoding (PC) are regulated.
- This is naturally linked to selective combining & comparing (KAC) and combination or comparison of stimuli (PC).
- Since we can observe forward and backward chaining if students try to link the schemes to the learning content, this can be described - at the metacognitive level - as selecting the adequate information representation mode. This is especially true if a scheme is an addition to the text in which the scheme content is discussed beforehand or when a scheme is commented by the learning contents that follow. The same knowledge elements are in this way presented by equivalent representation sets.

The following two support devices do not influence the immediate learning process :

- *Additions*
- *Content extensions*

They rather help to enrich the task environment.

When discussing the relevance of incorporating structure pages and content tables, we referred to the difference between micro- and macro-text-structures. The same discussion can be put forward if we analyze the impact of :

- *References to other learning units*

Metacognitive processes in relation to decisions on the information representation mode and monitoring (MC) and the knowledge acquisition components 'selective combining' and 'selective comparing' are incited.

- *Introductions to a block or unit*

Since this type of device is rather a coherent combination of other support devices it is not this relevant to operationalize its functions in terms of our model. We prefer to refer to the information we discuss in relation to the separate support devices.

- *Text structure (paragraphs)*

This support device can serve two major functions. At the one hand, it can be linked to the 'Style' device discussed later in this text. As such it is considered as a formal text device that is helpful to enter more easily into the text content. Selective encoding (KAC) and stimuli encoding (PC) are as a consequence supported. But providing structure to a text can also serve the functions discussed in relation to content tables and structure pages : selective comparing (KAC) and stimuli combining and comparison (PC) are invoked. Since adding structure to a text also affects the meso- and macro-level of text understanding, also the metacognitive components related to the selection of a mental representation are affected.

* Frase & Schwartz (1979, p.197) refer to the intervening reading process to shed light on the functions and effects of certain typographical cues (text segmentation & text indentation). Their tests of some research hypotheses suggest that text segmentation (paragraphs) aids comprehension; if indentation is added as an extra, no further significant learning effect is measured.

The remarks of Frase & Schwartz indicate the explicit direct link with the reading (comprehension) process.

- *Summaries* (outlines, overviews)

It is obvious that summaries support knowledge acquisition components, since the relevant information is put in a clear and structured context. It adds more abstract features to the actual representation of knowledge elements of the students. But of more importance is the fact that summaries also invoke other metacognitive components. Especially monitoring behaviour can be induced since the student can be helped to check whether his representational structure of the learning content is conform to what course developers have put forward.

The research literature about 'summaries' remains sparse but some authors pay some attention to this ESD. Their views are in line with the functions and effects hypothesized above.

* Hartley & Davies (1976, p.244) underscore the 'prologue' function of overviews. According to them overviews familiarize the central argument of new materials and prepare students for what is to come.
* Cordero et al. (1991, p.257) compare the functions of outlines with those of advance organizers.

The following set of ESD (illustrations, examples, Ou-style, writing style) comprises text additions, elaborations and extensions that influence the presentation of the learning content. Wright (1977) links the functionality of this set of ESD to the needs of different readers, thus stressing especially their facilitating role for the reading comprehension process. Van Hout Wolters & Willems (1991) indicate that this kind of ESD is important to advance the motivation of students. But these ESD also have an impact in relation to cognitive aptitudes.

- *text documentation*

Illustrating study texts with pictures is a typical example of *text documentation*. In an overview about the effects of pictures on adult learning, Alesandrini (1984) clearly links the impact of representational, analogical and arbitrary pictures to their role in conveying meaning. Most arbitrary pictures are, according to our classification considered as "schemes" (graphic organizers, structured overviews and hierarchies, networks and maps). In our conception, only graphs, charts and diagrams belong to the category of arbitrary pictures. Taking account of this terminological issue, we can now turn towards the functions and effects question :

* Duchastel (1981, p.11) projects three roles for illustrations in texts : (1) an attentional role (enhancing motivation and interest in the task); (2) an explicative role (clarifying complex relationships) and (3) a thus role (facilitation of thus retrieval and recall of ideas in a text).
* Glenberg & Langston (1992) have empirically underpinned the hypothesis that pictures help to build mental models and have a facilitative effect on text comprehension. : "pictures

help to generate or reinforce important inferences and that the probable mechanisms responsible for inference generation is a type of mental model". They also refer to the motivational functions.

* Macdonald-Ross (1977, p.60) focuses especially on graphics in texts (graphs, charts, diagrams, notations, etc.) : "a graphic device is seen as a canonical form of representing certain kinds of problems".

* Szlichinski (1979, p.254) focuses on the functions and effects of diagrams and illustrations. He explicitly alludes to the representational function : "As well as providing new information, pictures and diagrams can represent information in a simplified or organised form so that it can be conceptualized or mentally transformed in search of a problem solution (...)".

From this picture, we can derive the following functions and effects :

- As mentioned earlier this ESD can influence motivation.
- Very consistently, the authors point at the representational function; text documentation influences the selection of mental representations.
- Since text documentation is - in most cases - an extra representation of text elements, there is also an impact on the components related to the activity of inference of information : selective comparing and combining (KAC) and stimuli encoding, combining and comparing between stimuli (PC).
- Text documentation enrich the representational status of knowledge elements. At a higher level, depending on the kind of example (for instance a context is given where a specific content-element can be applied), examples can also influence 'applying' (PC) since they involve the student in an applicative process[8].

- examples

The role of *examples* in text can have a comparable impact as text documentation.

- Formal presentation style and Ou-style

The formal consistent presentation of study texts has an impact on cognitive processing.

* According to Wright (1977, p.127) it has an effect on the attentional selectivity of the learner.

* Bernard (1990, p.207) has demonstrated that this type of embedded support devices clearly shows how the learning process is linked to the reading process. In his research to detect the effects of graphical organizers (cf. schemes in our conceptual framework) and structural cuing (comparable to our definition of "style" : typography, spacing, underlining, styles and sizes of fonts, arrows, bullets, ...) they perceive an interaction effect with reading level. Low level readers do not seem to benefit from these ESD This brings Bernard to the conclusion that "they are only as useful as the needs they fulfil in learners who have both the desire and the ability to use them. Even in the presence of processing instructions, such adjuncts can fail to achieve their intended purpose with all learners." (1990, p. 216).

* Hartley & Trueman (1985, p.101) did research in detail the effect of headers (affirmative statements and questions, embedded or marginal position, ...). They could conclude that overall, headers are effective since recall, search and retrieval of students improved. But they explicitly did (ibid, p.152) not try to explain how this happened.

These authors indicate the impact on :

- the reading process;
- 'selective encoding' (KAC) and 'stimuli encoding' (PC);

- Writing style

The writing style of a text does not incite cognitive processes but helps to make the task environment more manageable, recognizable for the students. This type of support device especially enlightens the linkage between the reading and learning process when learning from text.

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[8] It can be argued that this remains limited to low level applications. It is not the student him/herself who did look up the application context.

5.4 Learning activities - teaching methods

A first group of support devices, in relation to the learning activities expected from a student, helps to clarify the task environment :

- *Indications about study load*
- *Indications about support provisions*
- *Additional exigences*
- *Facultative activities*

If this is done in very operational terms, this category can even affect metacognitive components : selecting a strategy for task performance. But in general, this kind of support devices is rather stated in general terms.

Two support devices explicitly refer to the way students can or have to approach the learning content :

- *Indications about learning approach*
- *Questions, tasks about learning approach*

If they are stated in concrete terms, we can expect that explicitly monitoring components are influenced. This can be e.g. information on what kind of steps ought to be taken to study particular information = selecting a strategy for task performance. Or, the student is told to link particular text parts to the objectives defined = monitoring.
Next to an impact on cognitive processes, these ESD help to define the task environment.

Three types of support devices in relation to learning activities have been researched intensively :

- *Pre-questions*
- *Post-questions*
- *Tasks*

A variety of characteristics of these devices seem to influence their function, efficiency and effectivity : e.g. the position in relation to the text (post-questions, pre-questions), their frequency, their level (related to facts, concepts or meaningful learning, ...), etc. We do not enter into this discussion in the context of this text part but rehears the potential value of these devices in terms of our model.

* Bernard & Naidu (1992, p.49) suggest that post-questions can benefit the achievement of knowledge and comprehension learning objectives.

* Prequestions invoke forward processes. These processes concoct higher-level text processing (Duchastel & Whitehead, 1980, p.41) and influence therefore especially the knowledge acquisition component. These questions are considered to help students to respond to and to reinterpret the learning content.

* Rickards & Denner (1978, p.331) point at forward and backward processes to distinguish between pre- and postquestions. The forward process generates a kind of process of retainment of learning materials due to a test taking orientation to the text. Backward processes invoke review processes.

* Winne (1983, p.259) could empirically state that : "there was validated evidence in this study that students used backward focusing strategy when exposed to adjunct postquestions in the text (...).".

Tasks are more comprehending jobs than the ESD 'questions'.

* Holmberg & Schuemer (1989, p.49) highlight especially the link between tasks (assignments in their research set-up) and motivation since they are expected to demonstrate the student that he or she makes progress.

In terms of our model, we can summarize this information about questions and tasks as follows :
- Questions and tasks clarify the task environment.
- Pre-questions especially serve the activation of knowledge acquisition components (KAC) since new content is explicitly processed by encoding, combining and comparing activities.
- Prequestions and especially postquestions and tasks invoke a large set of metacognitive components. It depends on the specific implementation of this ESD which specific (set of) component(s) is activated :
  - Recognizing that a problem exists.
  - Selecting lower order components for execution of the task.
  - Selecting a strategy for task performance.

- Deciding to allocate attentional resources.
- Monitoring.

- *Feedback*

It looks evident that this support device especially promotes the metacognitive components understanding feedback and monitoring. Some authors mention extra functions/effects.

* Elshout-Mohr (1991, p.309) links feedback to motivational issues.
* Bernard & Naidu (1992, p.48) do not agree completely with these authors when they state : "error correction is a more important justification for providing feedback than its reinforcement function".

5.5 Media

We focus on written study materials. But the nature of the learning content can exact the use of alternative media. It is obvious that here the quantity and quality of the representation system is important :

- *Use of additional media*
- *Support to the use of extra media*
- *Media-mix*
- *Media at the level of the learning units*

But since, the type of media-use projected here goes beyond the textual, we will not hypothesize about the functions or effects of these ESD. Only in relation to the following ESD, a more precise discussion is relevant :

- *Integration of media-use in course materials.*

If the media-use is really text-integrated, the student continuously has to and can switch between different representations of the same kind. The selective combining (KAC) and combining of stimuli (PC) is intensified to consolidate the knowledge base. At the higher level, decisions in relation to mental representation selection are invoked.

5.6 Evaluation

Since testing is part of the learning environment, student expectations about :

- *Mastery requirements*
- *Information about test format(s)*

play a major role in the explicitation of the task environment.

Evaluation is especially related to monitoring behaviour and the understanding of feedback (MC). So, the inclusion of :

- *Tests (formative tests, summative tests)*
- *Examples of correct answers*

is relevant to incite these cognitive processes.
At the same time, and comparable to questions and tasks, tests clarify the task environment.

Table 3a and 3b give an overview from hypothesized 'positions' that the ESD take in the Sternberg-model. The hypothetical functions/effects of each (set of) ESD are indicated with the letter X.

Table 3a : Theoretical functions of ESD

Embedded support device	*MC1 Ensn. of problem*	*MC2 Nature of problem*	*MC3 Select. lower order comp.*	*MC4 Select. strategy task perform.*	*MC5 Select. mental represen-tation*	*MC6 Activat. assoc. resources*	*MC7 Monitoring*	*MC8 Underst. internal & external feedback*	*EAC1 Selective encoding*	*EAC2 Selective combining*	*EAC3 Selective comparing*	*PC1 Stimuli encoding*	*PC2 Combine or compare stimuli*	*PC3 Applying*	*Task Environ-ment*	*Moti-vation*	*Reading compre-hension*
Starting conditions																	
Indications about required prior knowledge															x	x	
Indications about study skills required																	
References about required prior knowledge																	
Start level tests			x		x	x									x		
Prior knowledge state tests																	
Study contracts																	
Course introduction																	
Learning objectives	x	x				x	x		x			x			x	x	x
Learning content																	
Structure pages					x				x	x			x				
Content pages																	
Repeat units							x	x									
Registers and indexes					x				x			x					
Advance organizers					x					x	x		x	x			x
Schemes					x				x	x		x	x				
Additions															x		
Content extensions																	
References to other learning units					x		x			x			x				
Introductions to blocks/units																	
Text structure					x				x	x		x	x				x
Summaries					x		x										
Text documentation					x				x	x	x	x	x	x		x	x
Examples																	
Formal style / Ox style									x			x					x
Writing style																	x

42

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Table 3b : Theoretical functions of ESD

Embedded support device	*MC1 Estim. of problem*	*MC2 Nature of problem*	*MC3 Select lower order comp.*	*MC4 Select strategy task perform.*	*MC5 Select mental represen-tation*	*MC6 Allocat attent resources*	*MC7 Monitoring*	*MC8 Underst internal & external feedback*	*RAC1 Selective encoding*	*RAC2 Selective combining*	*RAC3 Selective comparing*	*PC1 Stimuli encoding*	*PC2 Combine or compare stimuli*	*PC3 Applying*	*Task Environ-ment*	*Moti-vation*	*Reading compre-hension*
Learning activities																	
Indications about study load																	
Indications about support provisions				X											X		
Additional exigences																	
Facilitative activities																	
Indications about learning approach				X			X								X		
Questions, tasks about learning approach																	
Pre-questions	X		X	X		X	X		X	X	X				X		
Questions																	
Tasks																	
Feedback							X	X								X	
Media					X				X			X					
Use of additional media																	
Support to the use of media																	
Media-mix																	
Media at the level of units																	
Integration of media-use in course materials																	
Evaluation																	
Mastery requirements																	
Information about test formats															X		
Tests (formative, summative)							X	X							X		
Examples of (correct) answers																	

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6 RESEARCHING THE LEARNING PROCESS OF STUDENTS IN A DISTANCE EDUCATION CONTEXT : METHODS AND INSTRUMENTS

In this chapter, we focus on the methods and instruments that can be used to research the actual use of embedded support devices when students in a distance education context are studying.
As stated before, the actual use of ESD in a distance education context has been hardly researched in a systematic way. We also mentioned the fact that ESD have been extensively researched in artificial contexts. Relying on the methods and instruments used in these restricted research contexts is not a straightforward and acceptable solution.

In our research context and in relation to our research topic we are looking for research methods and instruments that are helpful to collect quantitative and qualitative information about :
- which embedded support devices are used by students in a distance education context;
- the preferences of students for specific ESD;
- the extent of use of these embedded support devices;
- the order in the use of ESD by the students;
- the functions and effects students assign to the specific ESD;
- the opinion of the students about the quality of the ESD, incorporated in the study materials.

Since we collect information from students with varying background, experiences, professional activities, and so on, the research methods and instruments are to take into account a set of independent, personal variables. Also our theoretical model of the learning process in a distance education context did stress the importance of such individual variables. Therefore, in the next section of this chapter, we will first orient the discussion about the research methods and instruments towards the importance of these intervening variables.

Next, we will review the methods used by other researchers when researching related questions. We confront these alternative approaches with our exigencies and finally make an option for a specific method and related research instruments.

6.1 Intervening variables

Determining the actual use of E.S.D by students is influenced by a set of intervening variables (independent variables in our research set-up). Earlier research has displayed sufficient evidence to put forward the interference of two sets of such variables : variables related to characteristics of study materials and variables related to student variables.

6.1.1 Characteristics of study materials

The concept "study materials" alludes to the set of written materials used by a student. Since the overall design of study materials can differ widely when comparing research set-ups, a clear description of the content and structure of the materials is necessary. At the content-level, we can question whether findings are different if we compare a research-context set up in relation to technical sciences with a research set-up in the context of the law domain. Caution is therefore needed when generalisation of findings is expected. In relation to the structure-issue, in our research set-up, we use the ESD to describe the specific structuring of the materials. Also in relation to this aspect we have to be very explicit since materials tend to vary and this might have implications when findings are to be generalised. Marland, et al (1990) studied for instance the effects of working with highly structured (with many access devices) or less structured materials and this resulted in significant different learning effects.

6.1.2 Student variables

The way students approach and use study materials might be related to relatively constant differences between these students. In literature a variety of dimensions are used to describe these differences.
Clyde, et al, 1983; Holmberg, 1979; Kember & Gow, 1989; Marland et al, 1990; Pask, 1976; Vermunt, 1986; Watkins, 1984; Willems, 1989; etc.) :
- course-focused versus interest-focused;
- holist learners, serialist and versatile learners;
- deep-level processing versus surface-level processing;
- student conceptions about the study process;
- experienced versus novice students.

Other dimensions can be conceptualized, depending on the theoretical conceptions of the researchers and in which they position their research. Van Rijswijk & Vermunt (1987a, b & c) for instance have set up a research with open university students, working with an a priori framework about regulation mechanisms influencing the individual study processes. They classified the way students approach the learning process by using 4 dimensions :

- *regulatory processes* (self regulation of learning process and results, self regulation of processing of learning content, external regulation of learning process, external regulation of pursuing learning results, undirected learning)
- *processing strategies* (relating and structuring, critical processing, memorising and rehearsal, analytical processing and operational processing)
- *study approaches* (accumulation of knowledge, construction of knowledge, application of knowledge, cooperative studying, educational stimulation) and
- *study motives* (personal interest, certificate oriented, examination oriented, profession oriented and ambivalent).

The way students approach study materials are - following the Van Rijswijk & Vermunt theory - dependent on a unique combination of the relative positions student take along the 4 dimensions described (this combination can be conceptualized as a "learning style"). From the preliminary results of their study (Vermunt, 1991), these researchers derive implications about the impact of external regulation by design features of instructional materials (by using ESD). They question the relevance of such ESD But, it is to be stressed that this preliminary conclusion is an indirect derivation from their research data. The authors did not research the actual study process and the actual use of ESD They relied on data obtained from students who reacted on general "statements" about their study approach and customs and habits (the ILS - Inventory Learning Styles).

Next to variables related to the characteristics of the individual process, researchers also take into account other, more objective student variables : age, gender, initial study level, experiences with studying in a distance education context (number of years, number of courses), study motives, study environment (time. place).

To summarize this subpart about student variables, we can conclude that it is difficult to write about "the student" in a distance education setting. Controlling a large number of independent variables is necessary to extrapolate conclusions from research data.

6.2 Methods discussed in literature

In writing this synopsis about methods and instruments, we relied as much as possible on examples from research, set up in a distance education context. If experiences or information outside this context might be relevant for the actual discussion, we incorporate them also in this subpart. Evaluative reflections about the relevance of functionality of the information discussed in relation to our research set up will be postponed until we review all the information in part 6.3.

To constrain the variety of methods and instruments that are to be taken into consideration, a number of conditions and restrictions are put forward :

- The research method and instruments have to be able to gather data about the actual learning process at the micro-level. This means that data are gathered about the step-by step use or conceptions of students about the learning content and the didactical organisation of this content by each specific ESD
- We are looking for objective research methods and instruments.
- We pursue a high level of ecological validity.
- We are looking for research methods with a high validity level. Validity is certainly dependent on the number of "translation" phases (e.g. by looking for classes to summarize data) the research data passed through before they are processed.
- We are looking for a highly reliable research methodology. "Reliability" is dependent on the number of "translation" phases. If for instance a student tells afterwards what he thinks he had been doing, there is already a first "translation". If the researcher tries to write down the student comments, there might be a second "translation phase". If, next, the written data are catalogued, structured and categorized, the data pass through a third translation phase.
- Taking into account the time-consuming nature of qualitative research methods, a research method and instruments are to be selected that facilitate an efficient and effective processing of data without too great loss of information.

6.2.1 The diary method

The diary method implies that students - during a pre-determined amount of time (weeks, months) - take note of whatever they do in relation to their studying.

Clyde et al (1983) have used the diary method following this rationale : "In order to encourage free response from students, a relatively unstructured student diary was used. Participants were asked to record for each day the amount of time spent in study and the activities engaged in, and to make any comments. They were requested to fill in a separate sheet for each day they worked on the selected module of their external course. Included with each diary booklet were instructions on keeping diary, and sample completed diary pages.".
This research method demands a lot of time from the students. Moreover, for our research purposes in which we want to analyze the studying process at the micro-level, the diary method would imply that the students got an introduction to the ESD to recognize them en to determine whether, how and how often they used them. In addition, being aware of the use of the ESD would demand form the students a functioning at different levels (a study and a meta-study process), and the question is whether this is possible. Just & Carpenter (1977) stressed the unconscious nature of an important part of the reading process. Of course this poses the question whether students can be aware of parts of their study process.
But, the diary method could be a potential additional source of information, combined with other research methods/instruments.

6.2.2 Interview method

In interviews, students get questions about their study approach, conceptions, attitudes, etc. Interviews are helpful to obtain qualitative research data. Its advantage is that the responses of students can be checked, unclear questions can be rephrased.
A typical example of the use of interviews is the study of Marland et al (1990). To sustain the interview process and to increase the quality of the introspective answers of the students, videos were shown of the student him/herself at work while studying. Another example is the study of Vermunt (1991) who in a pre-study interviewed students about characteristics of their study approach. By using the phenomenographic method, he categorized their answers. The prize to be paid for the high quality of the research data is the high investment in time and energy to transcribe the student answers, to analyze and categorize, etc.

Also other disadvantages can be related to the phenomenographic method. The interaction with the student can influence the researcher to 'direct' student answers. Moreover, the analysis of student answers can be influenced by a priori conceptions, hypotheses and theories of the researchers about the phenomena studied. Next, one can question the students' ability to recapitulate his/her own study process.
It is possible to overcome these disadvantages by preparing in a rigid way the interview-sessions with pre-structured interview-schemes and a standardised interview-procedure. The second disadvantage can be

It is possible to overcome these disadvantages by preparing in a rigid way the interview-sessions with pre-structured interview-schemes and a standardised interview-procedure. The second disadvantage can be solved by managing the interview analysis by a team of researchers. The third disadvantage is difficult to overcome; in our conception it is possible to interview students about their study process if the interview questions are asked in relation to the students own study materials and after he/she is demanded to go through a specific part of the material already studied..

Taking into account these considerations, the interview method is a valuable and useful research method. An advantage is that with this method, we can focus on our specific research topic : the ESD

6.2.3 Questionnaires

Questionnaires are popular research instruments. At the Open university, the annual evaluative study involving about 2000 students is always based on questionnaires (Boon, et al, 1991). Questionnaires are also used for evaluation at course level (e.g. van Meurs, 1987)

In relation to our research topic, some examples are found in literature. The Vermunt research (1986, 1991) we already discussed in part 5.1.2, was based on the use of a printed list of "statements" in relation to which students had to react (agree - disagree). Willems (1989) used questionnaires to evaluate the impact of "learning tasks" to regulate the learning process. Again, the questionnaire consisted of "statements" (Operational versions of surface or deep-level approaches to studying). Duchastel & Whitehead (1980) used a two-page questionnaire about in-text questions. Also Meyer en Watson (1991) used questionnaires, an adaptation of the "Approaches to Studying Inventory (ASI)" of Entwisle & Ramsden. Other examples of questionnaire use can be found in Vermunt, 1986.

The problem with questionnaires is that there is no possibility to control the interpretation of the questions by students. Written supportive comments can be given, but enlarge the amount of information to be read.

If we project the questionnaire-method against our research constraints, some problems stated in relation to the diary and interview method can be repeated. Since we want to enter into detail in the actual studying process, a massive amount of open questions are to be answered by the student and processed by the researchers. Again, the ESD-concept would have to be explained in detail to the student, again expanding the questionnaire content. There is also no control over the extent to which students are able to recall what they actually did in relation to the ESD
An advantage of this method, is that the data gathering process is less demanding for the researchers. Also it is not very difficult to collect data that are reliable.

6.2.4 Objective measures for text comprehension and recall

Instead of focusing on process features of the study process, one can focus on product outcomes : what, how many and in what order do students **recall** after studying a study text. Researchers can vary the study texts between experimental groups by embedding different sets of ESD An a priori conception in using this methodology is related to the direct link between specific ESD and learning outcomes.
The research method based on analysis of recall tasks has been often used (Duchastel, 1979; Kintsch, 1974; Thorndyke, 1977; Vance, 1987). The results of these studies suggest that ESD that organize and structure the study process influence test scores (higher recall).
The speed by which students answer questions can be used as a measure about text comprehension and induce conclusions about the effectivity of ESD Frase & Schwartz (1979) and van Hout Wolters & Kerstjens (1990) have used such an approach. Other researchers focused on speed differences when reading easy or difficult study texts (Black et al, 1979; Daneman & Carpenter, 1983; Haberlandt e.a., 1980).

The evaluation of **text comprehension** is related to the research tradition about reading comprehension (cf. part 3.4 in this text). The method makes use of analysis of answers on open-ended or close-ended questions (Beck, 1984) or analysis of student written text summaries (Brown & Day, 1983). An overview of alternative techniques, procedures and instruments has been written by Rost (1989) and Singer en Donlan (1989).
Although this 'family' of research methods results in highly reliable measures, important questions remain

unanswered. At the theoretical level there is for instance no agreement about process features of the reading process that are linked to the outcome measures. Moreover, connecting this research method to our research context, it is to be admitted that the heavy reliance on the reading process aspects of the study process, makes the evaluation process more complex.

Although its merits, objective measures of text comprehension and recall are not very suited for our research purposes. Since we want to analyze process features of the study process in relation to ESD, indirect measures are not very useful.

This category of research methods could be chosen in a later phase of our research where we want to compare study text in which ESD are operationalized ir different ways.

6.2.5 Analysis of drop-out measures and achievement scores

Also this type of research methods is rather product-oriented instead of focused on the analysis of the actual study process. In that sense it is not completely in accordition with conditions that are mentionnned in part 6.2. But this method is often used, mostly in addition to other methods. Effectivity of study materials (and ESD) is directly related to dependent variables, such as the number of students taking an examination, the number of them passing the examination, etc.

In literature, examples of this type of research are found : Holmberg & Schuemer (1989) analyzed e.g. starter rates (speed with which tasks are returned), drop-out rate, completion rate and achievement scores. These measures were considered to be related to the "accessibility" of the materials. Persons & Catchpole (1987) and Scales (1984) used only drop-out rates.

The advantage of this research method is that the research data are easily collected with high reliability. But, the problem with this type of research methods is that the number of intervening variables that also influence the product outcome cannot be controlled. Many of these variables have nothing to do with the ESD As a consequence, the validity and reliability of this measure is questionable.

6.2.6 Subjective measures

Students can also be asked to give their ideas about ESD The difference with the interview and questionnaire method is that here we only ask for a subjective appreciation.

Holmberg et al (1982) asked for instance students and course developers about their opinion about a newly developed didactical elaboration of the study materials : "guided didactic conversation". In later research Holmberg en Schuemer (1989) used comparable questionnaires. Persons & Catchpole (1987) used Likert-scales to measure the "satisfaction with distance learning". Van Hout Wolters & Kerstjens (1990) also use subjective measures. They based their research on the opinion of students about an experimental condition.

Often, subjective measures are part of a questionnaire or interview. This kind of measures has certain advantages. The opinion of the students is not pre-structured by certain types of questions. But the data gathered in this way can vary to a too high extent to be able to draw consistent conclusions. The data will not be useful to derive information about the actual use, functions and effects of specific ESD

6.2.7 Thinking-aloud method

During a certain study task, students are asked to say aloud what they are doing, how they do it and why they do it. These student comments are recorded, catalogued and categorized.

This research method has been regularly used when studying independent learning (Simons et al 1985; de Jong en de Bil, 1989; de Jong en Ferguson-Hessler, 1989). A disadvantage of this procedure is linked to the question about the ability of students to grasp partly unconscious processes, going on at the same time. Only conscious, control-like metacognitive processes will be betoken. Another limitation of this method is the fact that thinking-aloud will distract, divert the student and endanger the ecological validity of the information obtained. As mentioned earlier, this method results in a huge amount of research data which are not easily structured and analyzed. The reliability of the data can also be questionable.

Considering our research issue, the thinking-aloud method does not seem to be an efficient and effective method to analyze the study process at the micro-level.

6.2.8 Registration of eye movements

Registration of eye movements results in a direct quantitative measure that can be used to map the attentional focus of one studying (reading). The use of a special electro-mechanical device helps to register the eye-movement and relative focus length on specific parts of a text.

Just & Carpenter (1977) used this method to analyze the reading process. Also at the Open University experiments are being set up with an eye-movement registration unit (Stolk, 1991). In this research project, the relation between text processing and picture processing is studied. Although interesting data can be obtained, there remains scepticism about the theoretical foundations of the relation between eye-movements and higher order processes. Also the ecological validity of the (complex and even annoying) research set-up can be questioned. Waller (1979, p.184) also points at the narrow focus on the micro-learning process : "in addition to being expensive, elaborate to set up, and obtrusive though, (these techniques) have been biassed towards micro-level reading". But theoretical and practical advances in this method might make it interesting in the (near) future since there are some advantages linked to this method: there are no problems caused by the fact that a person cannot report things what he is not consciously aware of and the data can probably be obtained with high reliability.

6.2.9 Analysis of student annotations in study materials

de Jong & Ferguson-Hessler (1989) used an original method to analyze study behaviour. They used the annotations students make next to study text to draw conclusions about the way students execute tasks in physical sciences courses. The researchers were able to distinguish between poor and good students on the base of their analyses. Annotations reflected the level of mastery of the knowledge domain.

A qualitative analysis of annotations implies a high level of domain expertise of the researchers. This might lead to reliability problems while interpretating the annotations. Moreover, this method can only be applied if 'making annotations' is part of the normal study and work process of the students. Otherwise, it interferes with normal study behaviour and results in unreliable and invalid research data.

6.3 Putting things together: opting for a research approach

Table 4 summarizes the information about the different alternative research methods. Seven dimensions are used to check the extent to which the method/instrument does or does not meet specific requirements. These seven dimensions are discussed in more detail below. The extent to which a method results in reliable data is not easy to determine. Therefore there is no collum with information about the 'reliability'. Some remarks on this subject are made in part 6.2.

Table 4 The alternative research methods/instruments in view of our research constraints

	1. Information	2. d irect I ndirect	3. (sub)conscious	4. Ecological validity	5. Transl. phases	6. Work student	7. Work researcher
Diary	-/+	d	-	+	2	--	--
Interview	+	d	-	+	2	+	--
Questionnaire	-	d	-	+	2	-/+	+
Objective measure	-	i	+	-	1	-	-/+
Achiev./drop out	--	i	+	++	3	++	++
Subjective measure	--	i	-	++	3	+	+
Thinking-aloud	-/+	d	--	--	3	-	--
Eye-movements	-	d	++	--	2	-	--
Annotations	--	i	-/+	++	3	-	-

1. The criterion 'information' refers to the extent the method is helpful to acquire relevant information to answer our research questions : analysis of the actual study process and the functions and effects of ESD. The richer the information, the 'better' the method. This criterion is of prime relevance and has to be met before considering the other criteria.
2. The distinction between (i)ndirect and (d)irect indicates whether a method researches in a direct or indirect way the use of ESD. Methods resulting in indirect measures do rather focus on product outcomes of the study process. Direct measures are obtained by using methods that focus on the study process itself. We prefer the latter.
3. The dimension '(sub)conscious' indicates the extent to which a research method is able to grasp the unconscious aspects of the study process. The eye-movement registration method is in this perspective a very efficient method since the attentional focus of students on specific text parts are registrated, regardless of the question whether the student is conscious about this.
4. Ecological validity questions the extent to which a research method influences the study process and study setting and to what extent result can be translated to 'normal' study situations. The complex set-up, required to register eye movements is in this perspective not a good option.
5. We stated earlier that we are looking for research methods with a high validity level. Validity is certainly dependent on the number of "translation" phases (e.g. by looking for classes to summarize data) the research data passed through before they are processed. Example : Despite the fact that researchers attempt to minimize the effect of such "translation phase", it remains sure that a small number of such phases results in more valid information. The thinking-aloud method is in this perspective a method that might put forward many problems.
6. 'Work student' refers to the amount of work a student has to invest to deliver research information. The better a method the less time-consuming it is.
7. This criterion evaluates how time-consuming a method is for the researcher to get the data and to process them. Is there, for instance, enough pay-off of the huge amount of time-investment in the analysis of thinking-aloud protocols? The better a method the less time-consuming it is.

The information in table 1 clearly indicates that the interview method is to be preferred.
Other methods do not meet the most important criterion 'information' and the requirements about minimal

validity. On the other hand, earlier experiences with the interview method indicate that its efficiency might be questionable. Also the fact that there is still one "translation phase" (retrograde introspection) by the student before the data are registered and processed, might put forward problems about reliability and necessitates to pay caution when interpreting the data and deriving conclusions.

Both shortcomings of the interview method can be met by :

- a rigid pre-structuring of the interview that clearly indicates what question is related to what variable(s);
- an in-built control strategy that helps to check consistency in student reactions;
- constructing the interview following a structure that evolves from the general to the very specific (at ESD level) aspects of the individual learning process.

In the next research report where we discuss the results of our empirical study, the elaboration of our interview procedure will show how we dealt with these potential shortcomings.

7 CONCLUSIONS

In this research report we have given an extensive outline of the theoretical base of a research project that focuses on the actual use of embedded support devices in study materials for students in a distance education context.
Embedded support devices (ESD) are a set of activating, structuring and motivating extras in study materials that are supposed to support the individual study process. A validation of the assumptions underlying the use of ESD in the design and production of study materials for the distance education setting is as yet not been found in literature, nor at the theoretical, nor at the empirical level.
In this research report a theoretical model is constructed that tries to describe and explain the potential functions and effects of specific ESD We opted for a cognitive psychological framework, linked to individual variables, variables in the task environment and variables related to the reading process. On the base of this model, consistent speculations about the functions and effects of specific ESD can be presented.

In the second part of this report, we will focus on the research approach to be adopted. A review of the literature and an analysis of alternative research methods and instruments resulted in a choice for the interview method. Constraints and problems in relation to this research method have been anticipated and suggestions made for meeting them.

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Appendix 1 Publications Ou

Here a representative set of publications presenting the rationale for the instructional design practice at the Ou will be presented.

Boom van den, G., Brink van den, H., Hummel, H., Kirschner, P. & Schlusmans, K. (1989). *Een reeks varianten voor het ontwikkelen van cursussen van de Open universiteit.* Heerlen : Open universiteit - Centrum voor Onderwijskundige Produktie.

Brink van den, H., Schlusmans, K. & Boom van den, G. (1989). *Een cursus ontwikkelen volgens de tekstboek-werkboek variant van de Open universiteit.* Heerlen : Open universiteit - Centrum voor Onderwijskundige Produktie.

Schlusmans, K. & Boom van den, G. (1988). *Een cursus ontwikkelen volgens het leereenheden cursusmodel van de Open universiteit.* Heerlen : Open universiteit - Centrum voor Onderwijskundige Produktie.

Linden van, C.J.F.M.J. (1987). *Onderwijskundige aspecten van cursusontwikkeling van de Open universiteit.* Heerle : Open universiteit - Centrum voor Onderwijskundige Produktie.

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Appendix 2 Key concepts

The key question of our research is how and to what extent **embedded support devices influence learning**.

Three key concepts can be derived from this research question : embedded support devices, influencing and learning :

- **Embedded support devices** : devices that are built in the written study material to help, motivate, etc. students. See chapter 2.
- **Influencing** : embedded support devices are expected to
  - facilitate learning in order to attain the learning objectives put forward or to
  - develop learning strategies (metacognitive) that are helpful to direct future learning.

- **Learning** : 'Learning' is defined as a continuous, intentional (but not always conscious) and experiential process that builds on a complex of cognitive processes during which knowledge is represented, knowledge representations are optimized, refined, recalled, and stored in memory, etc. Learning can be internally and externally regulated.
In defining learning, we use some extra concepts that need further refinement : 'cognitive processes' and 'knowledge'.

- **Cognitive processes** : As will be elaborated further in this text, we adhere to an information processing view on cognitive functioning. The theory of Sternberg is used to describe and structure our conceptions about these processes (cf. part xxxx).

- **Knowledge** : Knowledge refers to classes of declarative and procedural information. They incorporate facts, concepts, relations, structures, methods (skills) and attitudes of a very general/abstract to a very specific/concrete nature. Knowledge is always approached by means of representations of knowledge.

- **Knowledge representation** : In our conception, knowledge is constructed by the learner by representing information. This representation is the result of interaction with reality. The more experience the learner gains with this information the more elaborated, refined, abstract the knowledge representation becomes. This implies that we can distinguish representation levels depending on degrees of abstractedness. Knowledge at an optimal representation level is independent from a specific context, event, person, process, etc. More basic representation levels depend on the physical, tacito-motor, social, emotional, etc. experiences we have with reality[9].

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[9] This hypothetical process of knowledge representation resembles to a high degree the schema-theoretical approach. In the latter view, knowledge is constructed as cognitive schema. These cognitive schema are collections of propositions. Propositions are relational links between concepts. As in our view, schemata integrate experiential information from a variety of sources (declarative, procedural, situational and contextual (for a more extended overview of cognitive schemata theory in relation to self-instruction we refer to Martin, 1984).

Previous english reports published in this series.

The 'Prior Knowledge State' of students
and its facilitating effect on learning.
OTIC research report 1.2
F.J.R.C. Dochy, 1988

Variables influencing the indexation of the
'Prior Knowledge State' concept and a
conceptual model for research.
OTIC research report 2.2
F.J.R.C. Dochy, 1988

Students' views on Prior Knowledge.
OTIC research report 3.2
F.J.R.C. Dochy, W.H.L. Steenbakkers, 1988

Modularisation and student learning in modular
instruction in relation with prior knowledge.
OTIC research report 8
F.J.R.C. Dochy, L.J.J.M. Wagemans, H.C. de Wolf, 1989

The didactics of open education: Background, analysis
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Learning objectives for practicals in institutes of
higher education in the Netherlands: A descriptive
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Studies on the multi-functional nature of courses
in economics and the role of domain specific
expertise. Ex post facto research 1
OTIC research report 22
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OTIC research report 24
P.A. Kirschner, M.A.M. Meester, E. Middelbeek,
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The role of subject-oriented expertise. A study of
the impact of personal and contextual variables on
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of expertise. Ex post facto research 2.
OTIC research report 25
F.J.R.C. Dochy, M.R.J. Bouwens, L.J.J.M. Wagemans,
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Analysis of the quality and impact of expertise
in economics.
OTIC research report 26
F.J.R.C. Dochy, M.M.A. Valcke, L.J.J.M. Wagemans, 1991

The construction of knowledge state tests, knowledge
profiles and the measurement of the value added.
OTIC research report 27
F.J.R.C. Dochy, M.R.J. Bouwens, 1991

Mapping "Prior knowledge" or "expertise: a tentative outline.
OTIC research report 28
F.J.R.C. Dochy, 1991

Functions and effects of support in open learning systems.
Outlining current empirical findings.
OTIC research report 29
M.M.A. Valcke, F.J.R.C. Dochy, M.M. Daal, 1991

Quality and impact of expertise in economics:
a replication study with Ou students.
OTIC research report 32
L.J.J.M. Wagemans, M.M.A. Valcke, F.J.R.C. Dochy, 1991

Validation of knowledge profile dimensions: looking
for empirical evidence.
OTIC research report 33
F.J.R.C. Dochy, M.M.A. Valcke, 1992

Knowledge profiles of students with low and high
prior knowledge states.
OTIC research report 35
M.M.A. Valcke, F.J.R.C. Dochy, 1992

Comparing knowledge profiles of students studying
at a distance teaching university and a regular university.
OTIC research report 36
L.J.J.M. Wagemans, M.M.A. Valcke, F.J.R.C. Dochy. 1992

Epistemological-methodological issues related to
applied organizational research.
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R.M. van Meel, 1992

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